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Tool-Room Systems[1]

by

Franklin D. Jones[2]

This article is a review of the different systems adopted in many well organized machine-building plants of various classes and sizes to insure proper care and promote delivery of tools, and to prevent loss of productive time resulting from misplaced tools or poor equipment. The article deals with the arrangement of the tool supply rooms, different types of tool storage fixtures, classes of tools that should be cared for systematically, checking systems or methods of accounting for tools when in use, general practice in regard to grinding turning and planing tools to standard shapes, and other essential features.

ONE of the problems connected with the management of machine shops is the care of the numerous small tools used on machine tools and in assembling departments. As the "business end" of a machine tool is the cutting end, it is important to use tools that cut effectively and to keep the machine on the job; and when the parts produced in these machines are being assembled it pays to use reamers that ream, wrenches that are right as to size and fit, and good tool equipment in every department. These are the principal reasons why modern machine-building plants have tool supply rooms and systematic methods of caring for the many different kinds of tools used in machine shops. A store-room for tools of certain classes is found in almost every machine shop, but there is considerable variation in regard to the types of tools that are stored, the cooperation between the tool supply and manufacturing departments and the extent to which systematic methods are applied to insure the prompt delivery of tools in good condition. For instance, the tool supply room may be merely a place for storing small or auxiliary tool equipment when not in use, or it may be so managed that such tools are not only stored but maintained in good condition and delivered to the different manufacturing departments in such a prompt and systematic manner as to add to the efficiency of the entire plant.

Location and Plan of Tool Supply Room

When a machine shop has only one room or department where tools are stored, this should ordinarily be located in a central position relative to that part of the shop requiring the largest number of tools, provided the general construction of the shop will permit. If the plant is large enough to be divided into separate departments, the usual method is to have a tool crib in each one; frequently the department supply rooms are auxiliaries of the main supply room, which may or may not be a tool-room as well as a place for tool storage. Some shop managers prefer, even for large plants, one main tool storage department from which all tools are obtained. This method, however, has only been adopted to a limited extent and chiefly where the nature of the work is such that many tools are not used exclusively on any one line of work, but are required in various departments. In connection with this plan, as applied to a large shop, the tools should be delivered to the workmen, in which case the accessibility of the tool supply room is not so important as when each employe must obtain the tools required.

The storage of tools is generally under the supervision of the tool-room foremen in plants having toolmaking departments, and where there is a single tool supply room, this is often a department of the tool-room, but it should be separated completely from it by a grating or partition, and should be under lock and key. One arrangement which has proved satisfactory for comparatively small shops is to have the tool supply room in such a location that one window or opening for the delivery or return of tools is connected with the tool-room and the other window with the machine shop. The tool-grinding department of a medium- or small-sized shop is usually adjacent to the store-room or is practically a part of it. This department usually contains a drill grinder, a tool and cutter grinder for sharpening reamers, milling cutters, etc., and a universal tool-grinding machine for sharpening forged turning and planing tools, provided such tools are kept in the store-room. In the larger plants where the different departments have separate tool supply rooms, the grinding of such tools as reamers, milling cutters, taps, etc., is generally done in the tool-room.

In locating the bins, drawers, or racks for tools or supplies, it is important to place the sections which are to contain the tools in greatest demand nearest the delivery and receiving windows. The extent to which different classes of tools are used varies, of course, in different shops and depends to some extent upon the nature of the manufacturing operations. In

[1] For previous articles on tool-room systems published in MACHINERY, see "Tool System of Cadillac Motor Car Co." in the June and October, 1916, numbers.

[2] Associate Editor of MACHINERY.

general, such tools as drills, taps, reamers, gages, jigs, milling cutters and files are used frequently. If blueprints are kept in the store-room, these should also be conveniently located with reference to the delivery window. Attention to this matter of tool location prevents needless delay in delivering tools to the workmen.

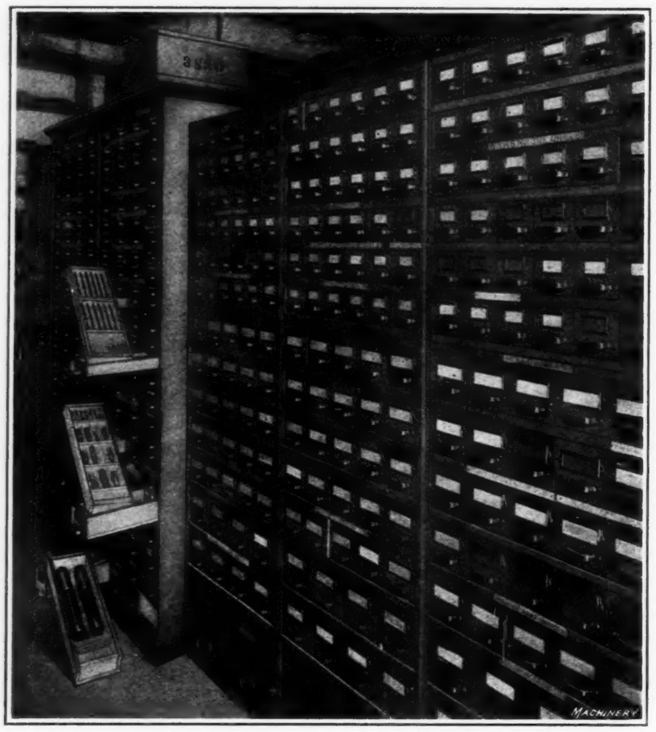


Fig. 1. Drill and Reamer Cabinets

Classes of Tools and Supplies Kept in Store-rooms

Tool supply rooms are generally intended for tools such as drills, reamers, taps, milling cutters, form tools for screw machines, box-tools for screw machines and turret lathes, standard and special gages, jigs and fixtures (except those which are heavy and cumbersome), punches and dies, new files, wrenches, lathe dogs, soft hammers, sledges, pneumatic hammers, and many other small tools of the portable class. In addition, there may be a variety of general supplies, such as standard bolts, nuts and washers, taper dowel pins, cotter-pins, brass, copper, iron or steel wire, and so on. In the larger plants supplies of the general classes mentioned may be kept in a separate department, and the tool supply room be used exclusively for auxiliary tool equipment, such as is required either in connection with machine tool operation or in the erecting department. Another method of handling supplies which is quite prevalent is to keep the principal stock in a supply room and a small stock in the tool cribs, the material which is stored with the tools being of the class that is needed continually by the manufacturing departments.

The variety of tools in any supply room naturally depends somewhat upon the class of work done in the shop or department with which it is connected. For instance, in some machine shops milling machines are used extensively, and consequently a large stock of milling cutters is required; other shops use a relatively small number of milling cutters, but a great many taps, reamers and drills, and there are many other similar variations.

Storage of Tools on Basis of Usefulness as Well as Value—When deciding what tools shall be placed in a tool supply room, several factors may be considered. In some shops the store-room is used only for tools which are valuable and which for the most part are products of the toolmaker. Such tools are cared for simply because they are valuable and perhaps easily deranged by careless handling. According to the modern idea of tool-room systems, however, tools are kept in a special store-room not merely because they are expensive to produce, but because of their usefulness and to insure prompt delivery of adequate tool equipment when needed, as well as to eliminate loss of productive time resulting from misplaced tools or fixtures. The rough bolts and clamps used on planers and other machines for holding castings and forgings to the machine table have little value so far as first cost is concerned; but if such equipment is not available when needed, or is in poor condition, the time of setting up a machine may be so delayed as to greatly increase the machining cost, and such delay may affect the work of other departments. In order to avoid difficulties of this kind, it is the practice in the more progressive plants to include in the stock of the tool store-room whatever small tools are essential to machining or assembling operations, even though they may not be expensive or of delicate construction. When the tool store-room is based on this plan, it is closely related to the various manufacturing processes and tends to increase the rate of production and general efficiency of the plant.

Storage of Large Jigs or Fixtures—While it is generally considered advisable to keep all small tool equipment in a special department, many shops, especially those in which heavy machinery is built, have jigs, fixtures or other tools which are too heavy and cumbersome to be moved to and from the tool supply room each time they are used; moreover, such large tools are often used exclusively in one department, and there is an advantage in having them near the machine to which they belong. Heavy tools that cannot be handled easily are often kept in a definite place on the shop floor, especially if they are used frequently or exclusively in one department; in other plants, auxiliary supply rooms are provided. It is a good plan to have all equipment of this kind, regardless of where it is stored when not in use, under the supervision of the tool supply department. While heavy jigs, fixtures, etc., may not be deranged as easily as smaller and more delicate tools, the fact remains that if no one is responsible for their upkeep, and systematic inspection is not provided for, minor defects often accumulate until, in some cases, the tool is in poor condition.

Storage of Clamps, Bolts and Packing Blocks—The clamps and bolts used for holding castings or forgings on the work-tables of machine tools, when special jigs or fixtures are not used, are kept at the different machines in many shops and often are moved from one part of the shop to another as they may be needed by different workmen. Ordinarily when such equipment is not cared for systematically, it is the direct cause of unnecessary delay in setting up machines. Bolts of the right length are often difficult to find and the threads become battered so that nuts must be run on or off with a wrench. Sometimes it will be necessary for a machine operator to re-cut a bolt with a hand die, and meanwhile the machine is idle.

Equipment of this kind should be kept in the tool supply room and be cared for the same as cutting tools, gages, etc. Where this plan is followed it is common practice to include, in addition to a stock of clamps and bolts of various sizes and lengths, packing blocks for the clamps. In some plants, a standard wrench is sent out with each set of bolts, clamps and blocks, so that the time for setting up a machine is reduced as far as possible. When bolts are returned to the supply room, each one should be examined to see that the nuts can be turned freely by hand.

Storage of Blueprints—Tool store-rooms are not only used for equipment of the general classes mentioned, but in many cases for keeping blueprints as well, especially in plants where duplicate machines are being built constantly. When blueprints are kept in this way they are usually given out in exchange for a check the same as a tool. A duplicate set of prints may be filed in the office of the machine shop foreman or superintendent for reference purposes only. These office prints should preferably be bound or filed together in sets, so that the foreman always has a complete set for his own use, instead of being obliged to refer to those which are scattered about the shop.

One method of handling blueprints which has proved satisfactory is to mount them on thin steel plates, heavy cardboard or wood. A thin material is preferable, owing to the relatively small space required for storage. Blueprints mounted in this way are protected while in the shop and they can easily be filed for future use.

In a great many machine shops blueprints are destroyed

when they are no longer needed in the shop for a certain job. The reason for destroying them instead of filing them away for future use is that in many cases the blueprints are either soiled or torn to such an extent that it is preferable to make new ones when they are needed again. Naturally the extent to which blueprints are soiled varies with the length of time they are kept in the shop, and may depend considerably upon the kind of work done, so that the practice of destroying them might not always be justified.

Storage Fixtures for Tools

The fixtures, such as racks, shelves, bins and drawers in which various kinds of tools are stored, should, so far as possible, be compactly arranged, in order to economize in space. The light should also be distributed evenly so that there are no dark shelves or bins, and it is important to arrange each fixture in such a way that the tools may be removed without difficulty. Each tool or tool set should have a definite place in the tool cabinet and provision be made for identifying and locating different classes of tools. A common method of marking different sections of a tool supply room is by means of letters and numbers, the letters indicating main sections and the numbers showing the location of racks, bins, drawers or other storage places in each section.

General Arrangement of Storage Fixtures—When designing storage fixtures of any kind, it is advisable not to conceal the tools any more than is necessary, although drawers or trays are often considered preferable for small drills, taps, reamers and other tools that might be lost or misplaced if kept in open bins or shelves. Shelves or box-shaped enclosures should be large enough to permit the hand to be inserted without interference. Trays or open shelves for small tools should have shallow or low partition strips for separating different sizes of tools, and if such receptacles slope toward the front the tools may be seen better and removed more easily. Edged tools, such as reamers and milling cutters, should be separated so that they will not strike against each other. Reamers, taps, etc., are sometimes held vertically by inserting the shanks in holes made in a special rack; such tools are also kept in trays or drawers having low partition strips to prevent direct contact between different tools. Fig. 1 shows reamer and drill cabinets in a tool supply room of the Cadillac Motor Car Co. The reamers are placed in separate pockets formed in crosswise strips so that they do not roll against each other and thus injure the cutting edges (see the three drawers to the left which have been removed).

The height of tool racks and cabinets usually varies from five or six feet to the height of the tool supply room ceiling. Low racks (see Figs. 2 and 3) are usually found in shops having plenty of space. A ladder supported by a track and rollers is convenient for high racks such as are found in many city shops, located where land and space have a relatively high value. (See Fig. 23.) Wood is generally used for tool racks and cabinets in tool supply rooms, although many of the new plants have steel shelving.

Unit System of Construction—Most tool store-rooms have fixtures which are of permanent construction. It is desirable, however, to so construct the storage equipment that it can be rearranged and expanded to accommodate a larger stock of tools, if this should be necessary on account of the growth of a plant. This unit system of construction, as applied to the tool supply room of the Tabor Mfg. Co., Philadelphia, Pa., is illustrated in Fig. 4. The tool cabinets consist of a main rack having square sections which may be sub-divided for storing different types of tools by means of boxes, trays and drawers of standard size. The sections or compartments of the main rack are 24⅝ inches square and 17 inches deep. These racks are made of wood and are rigidly constructed, as they sustain heavy loads when filled with tools. The boxes which are inserted in these square compartments for holding certain classes of tools are made in fifteen standard sizes, as given in Table I.

Fig. 4 shows some of the combinations that are possible with this construction; thus, section *A* is fitted with sixteen square sections or boxes, section *B* has eight rectangular boxes, section *C* four square boxes, and so on. The compartments are fitted with whatever combination of boxes is best adapted to the size and number of tools they are to contain. The tool rack shown in Fig. 5 also illustrates the flexibility of the unit system of construction. When drawers can be used to better advantage than open boxes for the storage of small tools, cutters, etc., these are inserted in double vertical rows as shown.

Racks for Clamping Bolts and Packing Blocks—Fig. 6 shows the form of storage racks used by the Tabor Mfg. Co. for clamping bolts such as are often required for holding castings or forgings on the work-tables of machine tools. The bolts are suspended from T-slots formed in the standard storage boxes used at this plant. The symbol for each size of bolt and the hooks for the workmen's checks are placed adjacent to the various compartments. The method of keeping packing blocks is shown in Fig. 7. Standardizing equipment of this kind is of especial importance in shops doing general work for which special fixtures have not been constructed.

Cabinets and Racks for Milling Cutters—Many tool supply rooms have cabinets of the general type shown near the delivery window in Fig. 8 for storing milling cutters. These particular cabinets are of octagonal form and each of the eight sides is covered with cutters suspended on pegs. As the cabinet can be revolved about a vertical axis, any side may be reached easily. The swinging or folding door type of cutter rack illustrated in Fig. 10 is now used quite extensively. These swinging doors are hinged to a vertical shaft and each door provides two sides for the storage of cutters. Another compact design is similar in construction to the familiar sliding barn door. Each door of the cabinet has wheels above and below it which engage horizontal tracks for guiding the doors as they are rolled in or out. There are several parallel doors arranged in a group with a space of about twelve inches between them. The cutters are suspended upon pegs or hooks. Fig. 9 shows milling cutters stored on shelving. Different types are grouped together, and these groups are plainly

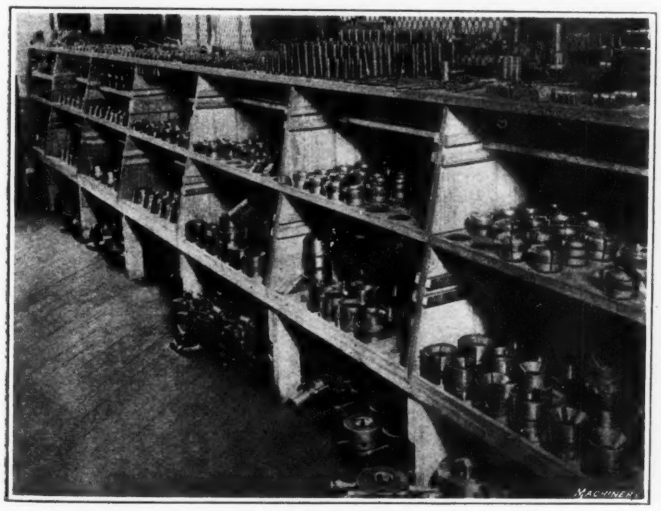


Fig. 2. Collet Rack

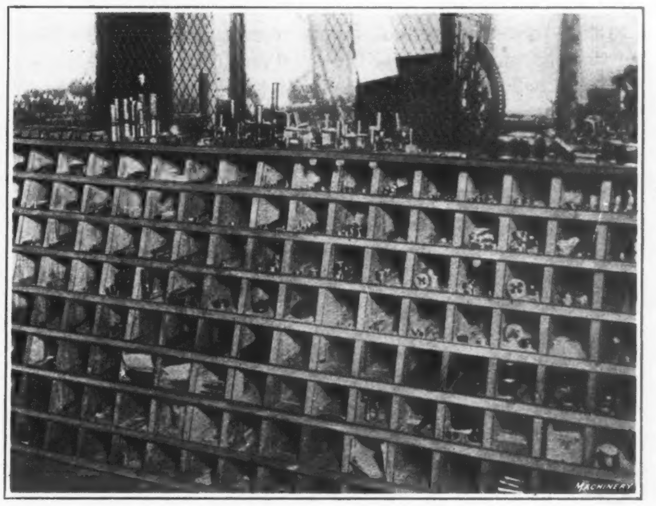


Fig. 3. Tool Rack of Open-bin Type

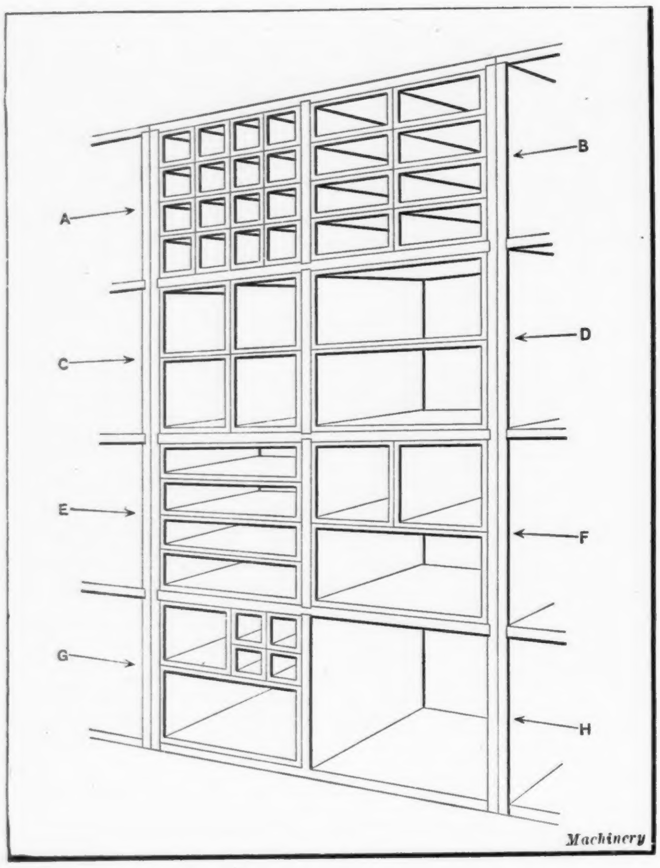


Fig. 4. Diagram illustrating Unit System of Construction for Tool Racks

marked. Instead of placing the cutters loosely on the shelves, they are provided with removable holders consisting of base blocks and vertical pegs which pass through the cutter-arbor holes.

Racks for Taps and Dies—The rack for taps shown in Fig. 11 is so arranged that the taps are held in position by their shanks, which are inserted in holes of suitable size. This form of rack (which is used by the Cleveland Automatic Machine Co.) prevents taps from being nicked or otherwise injured by striking against one another. Each tap has a label giving its size, and there is also a hook for receiving the workman's check when the tap is in use. A rack for spring screw-threading dies is shown at the left of Fig. 11. The hollow shanks of the dies fit over pegs on the rack which hold them in position.

Racks for Snap Gages—A good type of rack for snap gages is shown in Fig. 13 (see upper part of cabinet). Metal partitions are used to separate different gages, the height of these partitions and the space between them being varied in accordance with different gage sizes. These partitions extend across the shelf at the bottom, but curve backward toward the top, so that the upper ends of the gages project far enough to be easily gripped for removing them from the cabinet. This form of rack is found in the tool supply rooms of the Cadillac Motor Car Co. Incidentally, this illustration shows how steel partitions can be used to form compact bins or compartments of the general type shown just below the gage rack. The consecutive numbers of the bins are stamped on circular checks or tags suspended from rings so that they are free to swing and do not interfere with the insertion or removal of the tools. Fig. 11 shows (at the right of the tap rack) a form of snap gage rack used by the Cleveland Automatic Machine Co. The gages are held in place by boards having slots on the edges into which the gage jaws are inserted.

Rack for Storing Blueprints—When blueprints are kept in the tool store-room they are often filed in drawers, but this is an inconvenient and troublesome method and requires more room than is necessary. When the drawers are filled with blueprints it is difficult to prevent them from curling up and catching when the drawer is pulled out, and occasionally a blueprint will slide out at the rear end. In a shop where considerable trouble had been experienced with blueprints stored in shallow drawers, the rack illustrated in Fig. 12 was installed and proved very satisfactory. This rack is made of 2- by 4-inch timbers to which are secured a large number of sheet steel strips upon which the blueprints are suspended as indicated by the illustration. The lengths of these steel strips are varied in accordance with the size of the blueprints, the largest prints being at the bottom of the rack and the smallest ones at the top. The numbers of the prints were written on "stickers" and pasted on the steel strips or arms.

Tool Checking Systems

In every tool store-room it is essential to have some systematic method of determining what tools are in use and where they are located in the shop, to prevent loss of tools and to enable any tool to be found readily if necessary. The method which has been adopted almost universally is to use brass checks which are numbered to correspond with numbers given to different workmen. These checks may be placed in the store-room tool cabinet where the tool belongs, or they may be filed on a board in the store-room, so that the number of tools in the possession of any particular workman may readily be determined. There are various modifications of this checking system which are intended either to simplify

TABLE I. DIMENSIONS OF STANDARD BOXES AND TRAYS[1]

Number of Box	Outside Dimensions, Inches	Number of Box	Outside Dimensions, Inches
1	24 by 24	9	12 by 4
2	24 by 12	10	8 by 8
3	24 by 8	11	8 by 6
4	24 by 6	12	8 by 4
5	24 by 4	13	6 by 6
6	12 by 12	14	6 by 4
7	12 by 8	15	4 by 4
8	12 by 6	..	....

Machinery

[1] The length or depth is 17 inches or less in all cases.

Fig. 5. Rack illustrating Flexibility of Unit Construction

the system, or to make it a more effective means of accounting for tools and of preventing mistakes or fraudulent practices.

Single Check System—The single check system, as commonly applied to tool-rooms, is so arranged that each workman has a certain number of checks which he receives when first employed. These checks, as previously mentioned, are stamped with the employe's number, and whenever he obtains a tool from the store-room, a check must be given to the tool-room attendants as a receipt. This check, according to the usual method, is placed on a hook located where the tool belongs in the bin, rack or drawer of the cabinet. When the tool is returned to the tool-room the check is given back to the workman. If the tool should be sent from the tool-room to the grinding department or forge shop, a special tool-room check is either put in its place or a written record is kept; consequently, the location of every tool not in the store-room is shown either by the number of the workman's check or by a tool-room check or a separate record.

Use of Checks and Tool Tags—Instead of placing the employe's checks in the tool racks where the tools belong when not in use, they are placed on a check board in some tool supply rooms. One system which has proved satisfactory in a large plant where there are many tool supply rooms for the different departments is as follows: The bins or other storage places for all tools are numbered consecutively and for each special tool there is a card in the tool supply room and also a tool tag. These tags and the cards are used in connection with the delivery of the tools to the employes. The cards show the names and numbers of the parts on which the tools are used, the names and numbers of the tools, and the bin numbers for locating the tools in the supply room; these cards are filed numerically according to the part numbers. The tool tag for each special tool is marked with the name of the tool and its number. There is a check board for special tools and another for commercial or standard tools. The tool tags are filed on the check board for special tools. Whenever an employe receives a special tool, his check is placed on a hook of the check board over a tool tag marked to correspond to the number of the tool. Numbers stamped on the different

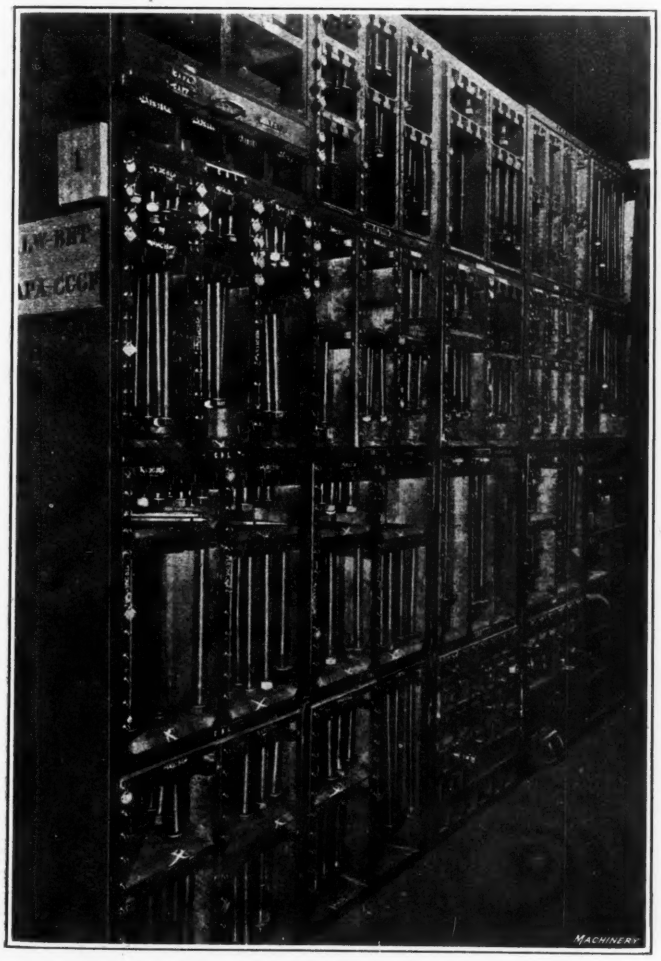


Fig. 6. Rack for Clamping Bolts of Various Lengths

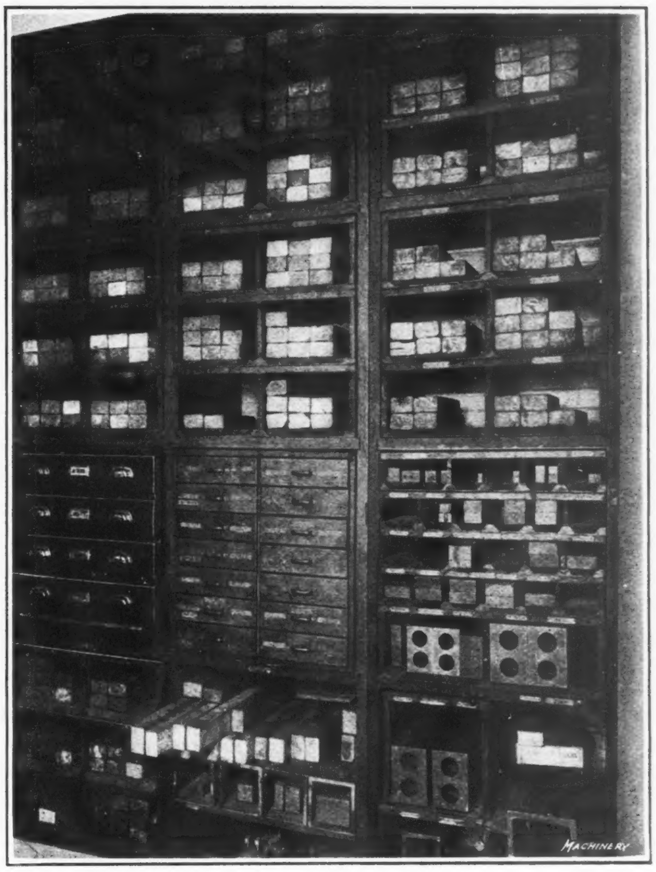


Fig. 7. Packing Blocks kept in Tool Supply Room

tools may be used to identify them or determine their location in the supply room by referring to the card file. The commercial tool check boards are arranged in alphabetical order according to the names of commercial tools, using the noun in each case; different hooks may represent different sizes, as in the case of drills.

All Checks Kept in Tool Supply Room—The most common objection to giving checks to workmen is that they are sometimes lost or borrowed. A lost check may cause considerable trouble, especially if it is found by some other workman who uses it in a fraudulent way. Deception might be difficult in a small shop, but in a large plant the store-room attendants might not know whether the proper check was received or not. In order to prevent checks from being misplaced or lost, it is the practice in many plants to charge a certain amount for each check that is missing when the workman leaves the employ of the company.

In order to avoid the difficulties resulting from losing them, checks are not given to the workmen in many shops, but are permanently kept in the tool store-room. Each man is allowed a certain number of checks, which are usually kept on a check board in the store-room. This board has a hook or slot for each man who may require tools, and there is some kind of record or card file showing the names of the workmen corresponding to each check number. The names, in many cases, are on the check board. When a man calls for a tool, one of his checks is removed from the board and is put in the place occupied by the tool, for which a hook is usually provided. When the tool is returned by the workman, the check is removed from the tool cabinet and is replaced on the tool-room board. While this system prevents the loss of checks by workmen, it is not faultless, as carelessness on the part of the tool-room attendant will sometimes result in misplaced checks, or failure to return checks to the board when the tools are returned by the workmen.

There is another method of keeping all checks in the tool-room which differs from the one just described in that the checks are placed on the check board when the tools are delivered instead of being hung in the vacant places of the tool cabinet. A board large enough to receive tags bearing the names of all the men requiring tools is placed in a con-

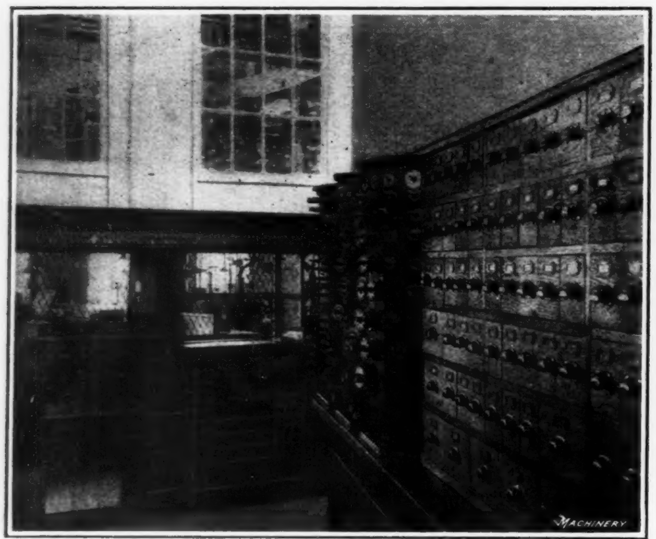


Fig. 8. View in Tool Supply Room showing Revolvable Racks for Milling Cutters

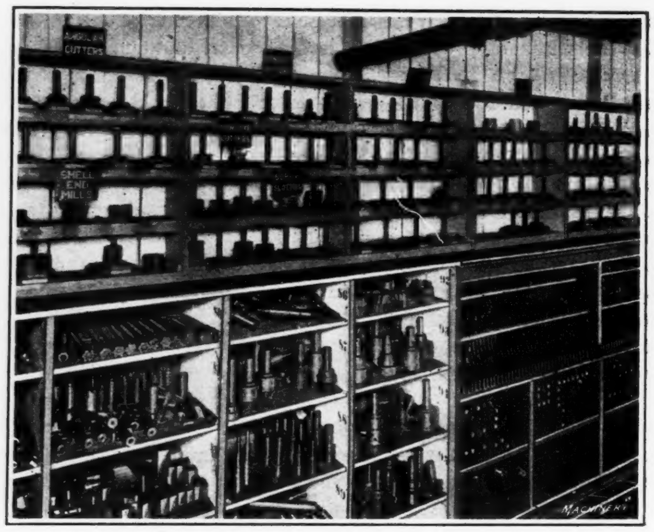


Fig. 9. (Upper Section) Method of storing Milling Cutters on Shelves by Means of Special Holders

venient location and opposite each name there is a hook for receiving checks whenever tools are delivered. The tools are all numbered and the checks are numbered to correspond. When a tool is delivered, the check which bears its number and hangs near it is removed and placed on the board opposite the name of the man to whom the tool was delivered. When this tool is returned the check is removed from the board and hung in its place in the tool cabinet.

Checks having Different Exchange Values—When a number of tools are required by one workman, special checks are sometimes used, one arrangement being to have the workman's number on one side and numerals on the other side indicating the number of tools received. For instance, the reverse side of checks may be numbered 2, 3, 4, 5, etc. If the workman's number is 50 and he should require four tools, the check given to the tool-room attendant would have the number 50 on one side and 4 on the reverse side, the latter number showing that he has four tools of the kind belonging in that particular section of the tool cabinet where the check is placed. These special checks should be of a different size and shape from those ordinarily used so that the attention of the tool-room attendant will be directed to the numeral on the reverse side of the check when the tools are returned. The exchange value of the check may depend entirely upon the shape instead of numbers.

Double Check System—When a single check is exchanged for a tool and is placed where the tool belongs in the tool cabinet, it might be impossible for the man in the tool supply room to determine how many tools a workman has in his possession without examining the entire stock of tools, providing there were no separate record. The double check system shows the number of tools received by each workman and for that reason is preferred in some plants. Double check systems vary somewhat as to details, but the methods here described give the general principles.

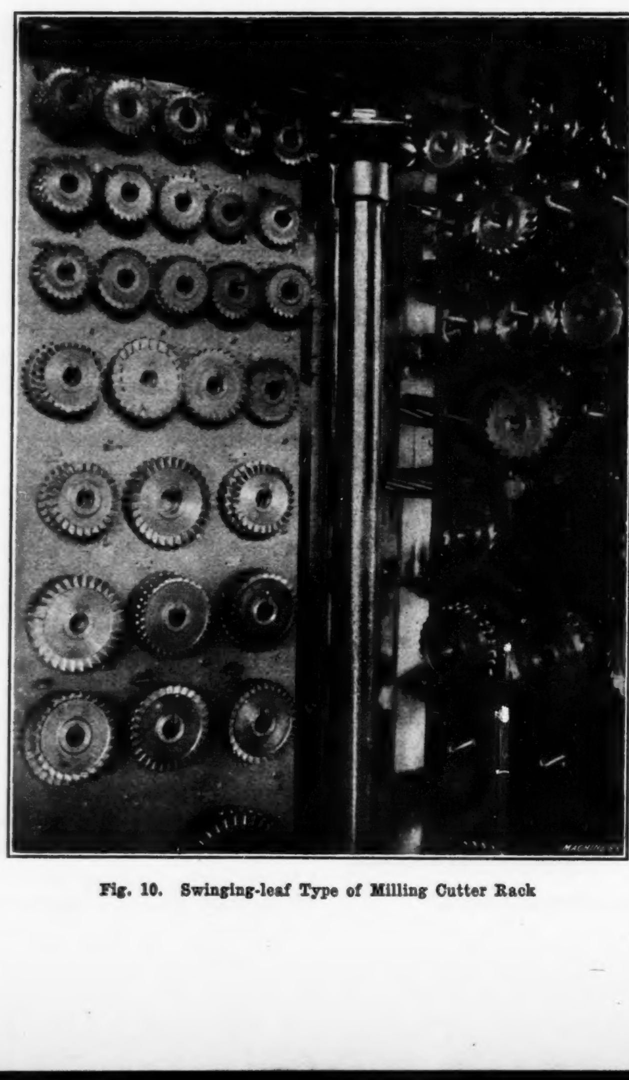


Fig. 10. Swinging-leaf Type of Milling Cutter Rack

With one system there is a board in the tool store-room which has two check hooks for each employe and near each pair of hooks there is a label giving the name of the employe and the corresponding check number. When a man is engaged by the concern he is given a certain number of round checks, and a corresponding number of square checks are hung on one of the hooks opposite his name on the store-room board. Whenever a workman receives a tool, he gives a round check in exchange for it and this check is placed on the hook adjacent to the man's name and number. At the same time, a square check from the opposite hook is removed and inserted in that part of the tool cabinet from which the tool was taken. When this tool is returned, the square check is replaced on the board and a round check on the other hook is given back to the workman. With this system the number of round checks hanging opposite each name shows how many tools that particular man has in his possession, without searching through the tool cabinet. The square checks, which are also numbered, show who received the tools that are not in the tool racks.

Another double check system, which is a modification of the one just described, differs from it in regard to the method of filing the checks. Each employe receives a certain number of checks bearing his number, and there is a check for each tool in the store-room which hangs near the tool when the latter is not in use. In the store-room there is a board with each employe's number on it and a single hook adjacent to each number. Upon the receipt of a tool from the store-room, the workman gives a check which is placed on the hook in the tool cabinet where that particular tool belongs. At the same time, the tool check from the cabinet is hung on the hook adjacent to the employe's number on the tool-room board. When the tool is returned the exchange of checks is made in the reverse order. If a tool that is out in the shop is wanted by some other workman, the man in the store-room can readily

Fig. 11. Racks for Taps and Snap Gages

Fig. 12. Rack for Storage of Blueprints

tell who received it and the tool-room board also shows how many tools are in the possession of each employe, which information might be of considerable importance in case a man were leaving the employ of the company. A double check system is sometimes preferred in large shops, especially where men are leaving constantly.

An Exchange of Checks—There is another modification of the double check system which is based on an exchange of tool checks and employe's checks. Each workman is provided with a certain number of checks, the same as in the system just described. Near each tool in the store-room, checks of special shape are kept on suitable hooks. The name and size of the tool is stamped on each of these tool checks. When a workman requires a tool he exchanges his check for the tool, which is also accompanied by the tool check. This system is intended to prevent mistakes on the part of the store-room attendant, such as placing the wrong check on the hook of some missing tool and holding the wrong man responsible for it, because the check accompanying each tool is a receipt for the man who obtains the tool.

Double Check System with All Checks in Tool-room—The double check system, as well as one requiring a single set of checks, may be so arranged that no checks are allowed in the possession of the employes who are thereby prevented from losing them. One method requires the use of two check boards, each having a number of hooks corresponding to the number of employes using tools. Each hook on what is known as the "in-board," contains the same number of checks, the number usually being ten or fifteen. The hooks on the "out-board" are intended to receive checks representing the number of tools delivered. As each man is engaged by the company, he is given an identification number which establishes his identity in the tool supply room. Every tool in this room is identified by a small check which is kept with the tool when the latter is not in use. If, for example, employe No. 50 is given a reamer, a check from hook No. 50 on the "in-board" is transferred to hook No. 50 on the "out-board," and on the same hook on the "out-board" is placed the check for identifying the tool. With this system, the man in the tool-room can readily determine how many tools are out, the type of tool and to whom they were delivered. When a man leaves the employ of the company, a receipt from the tool-room showing that all tools have been returned must be presented to the time-keeper before the man is paid.

Checks which show how Long Tools have been Out—In order to determine the length of time tools are kept by workmen, special checks may be used in conjunction with the regular checking system. These checks, which are of special form and kept in the store-room, are numbered from 1 to 31 to correspond with the days of the month. When an employe receives a high-grade or expensive tool, such as a standard gage, his check is filed where the tool belongs, and a special check showing the day of the month on which the tool was delivered is placed in the tool cabinet. If the tool has not been returned at the end of the month, the workman is notified, and if he still needs the tool it must be taken back to the store-room before he uses it again; another "date check" is then placed in the tool cabinet, thus indicating that this particular tool was again delivered on the first of the month.

Written Receipts for Tools

Written receipts are preferred to metal checks in some shops. One method is to place printed slips or forms in suitable boxes which are conveniently located about the shop. When a tool is required, the workman writes the name of the tool on the slip, his check number, the date and his signature. When a tool has been received, the slip is given to the store-room attendant. One method is to file these slips in numerical order according to check numbers, back of guide cards showing the various classes of tools. When the tool is returned the slip is removed from the file and given to the workman who destroys it. A sample order blank for tools used in connection with a system of this kind is illustrated in Fig. 14. The names of tools most commonly used are printed on the order and the names of other tools are written on the blank lines provided.

In some plants the receipt is not given back to the workman when the tools are returned, but is transferred

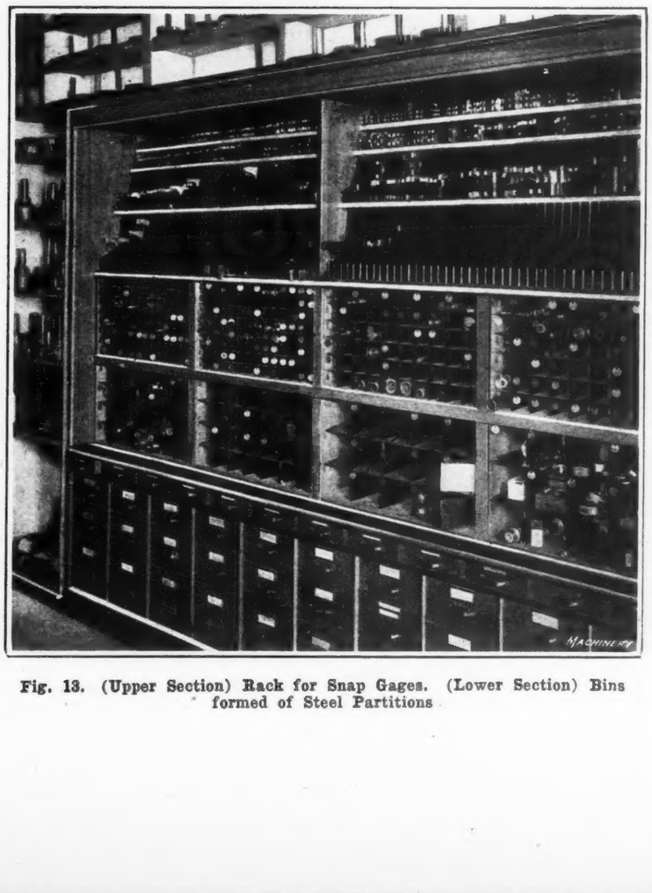
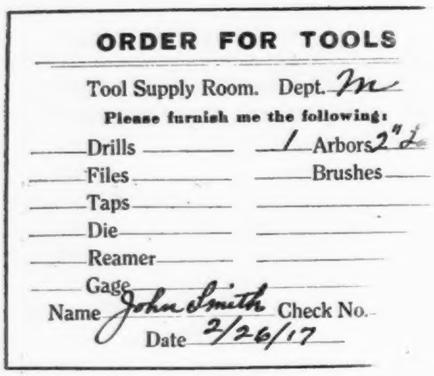


Fig. 13. (Upper Section) Rack for Snap Gages. (Lower Section) Bins formed of Steel Partitions



ORDER FOR TOOLS

Tool Supply Room. Dept. M

Please furnish me the following:

Drills	1 Arbors 2" L
Files	Brushes
Taps	
Die	
Reamer	
Gage	

Name John Smith Check No.

Date 2/26/17

Fig. 14. Written Order for Tools which is used instead of Brass Checks

from one file to another and is kept as a permanent record. In case the workman receives supplies which are not returnable, such as pipe fittings, etc., a different order blank is used and instead of transferring it to a permanent file, as is done with the receipts for returnable tools the order or requisition is sent to the accounting department so that the supplies can be charged against the particular department which receives them.

Delivering Tools to Workmen

In most machine shops tools are obtained from the supply room by the workmen who use them, but tool-room boys are sometimes used for delivering the tools and returning them to the supply room. In connection with this system an annunciator or other electrical signaling device should be used. An annunciator is placed in the tool supply room and connected by suitable wiring with push-buttons located throughout the shop. When an employe wants a tool he presses the nearest button and may hang his tool check on a hook near this push-button. The annunciator shows which one of the buttons was pressed and a tool-room boy goes to that part of the shop and finds out what tool is required. If the tool is of special design it is the general practice for the workmen to designate it by a number or symbol of some kind which is found either on the blueprint or on a list of operations accompanying the blueprint. This number or symbol enables the man in the tool supply room to locate the tool or set of tools, as the case may be, either directly or by referring to a card file or other record.

Delivery of Tools in Sets

In shops where machines and parts are manufactured in duplicate it is economical to provide some systematic method of issuing tools in sets which include all the tools required for a series of operations on any part. In some cases special tools are kept in sets permanently, but usually such sets are made up of both standard and special equipment and the standard or commercial tools are used singly as well as in sets. For instance, a set of tools may consist of a drill jig, several drills and reamers and one or more taps. In this case the jig and possibly a reamer might be special and the other tools of standard or commercial forms and sizes. When a great many duplicate parts are produced, if sets of tools are kept together permanently, obviously a large stock will be necessary. To reduce the stock of tools, the standard types are often used either separately or in conjunction with the different special tools to form sets which may be needed for manufacturing operations.

In connection with the delivery of tools in sets, it is essential to have records that will enable the man in the tool supply room to collect the tools quickly for any regular manufacturing operation. If the operations are on a new part or on a series of parts, the department which decides what tools are to be used should provide the tool supply room with a list which may be used as a guide in collecting that particular set of tools, provided they are not kept permanently in sets. The tools used for screw machine operations, such as box-tools, form cutters, etc., are often kept in sets with a record of the "set up" for future reference. In the plant of the Tabor Mfg. Co., the planning department, which decides the kind of tool equipment for each job, issues a list of tools which is sent to the tool supply room prior to the time that these tools will be required in the shop. With this system (which will be described in detail later) the set of tools is made up in advance so that no time is lost when the tools are actually needed in the shop.

Special Boxes for Sets of Tools—With the system of issuing tools in sets adopted in the plant of the Cadillac Motor Car Co., many sets of tools for different manufacturing operations are placed in boxes (see Fig. 18) which are delivered to the workmen in exchange for checks. If the special and commercial tools for operations on any part are of such a nature that the use of a box is practicable, this box is given a number and a list of its contents is placed on the inside of the cover. These box numbers are listed upon cards representing special tools which are arranged in files under the part numbers. Part numbers are given to every part of the automobile and are used, in conjunction with tool numbers, to identify different special tools. For instance, if the foreman of the drill press department wants to begin work on part No. 12,800, this number is given to the man who goes to the tool supply room after the tools for whatever operations are to be performed on this part. The attendant in the tool supply room refers to a card in the file of special tools which is marked with this part number and shows the number of the box containing the set of tools. These boxes are stored in numerical order and on racks built for the purpose (see Fig. 15) so that any box can be found readily. The tool list on the box lid shows what tools remain in the box and what tools belong in the regular tool racks. Ordinarily, the special tools are kept in the boxes while in storage and the commercial tools are distributed, although some commercial tools are also kept in the boxes permanently.

If it is not practicable to keep a set of tools in a box, a tool list is used which shows all the special and commercial tools required for any part number or operation number. These lists are made out in duplicate, one copy being for the tool supply room and the other for the department foreman. (See Fig. 19.) The tool lists which are on file in the tool supply room (arranged under the part numbers) are kept in linen envelopes, and when tools of any list are in use, the employe's check is placed in the envelope with the list. All the tools on a list may be covered by one check and all must be accounted for before this check is given back to the work-

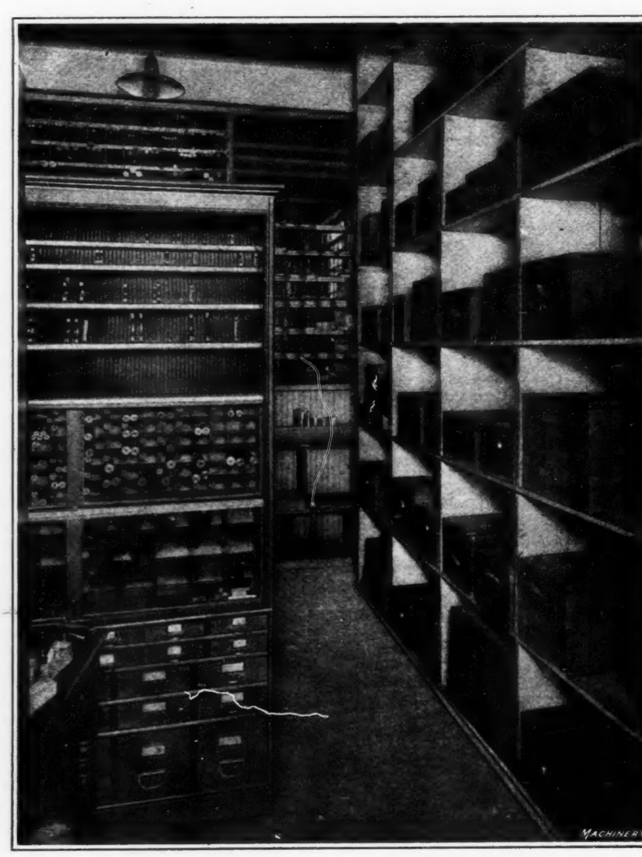


Fig. 15. (Right-hand Section) Storage for Boxes in which Sets of Tools are delivered to Manufacturing Department

man. The tools handled in this way are asked for somewhat before they are actually needed, so that the tool supply room attendant will have time to collect the tools in a tray before they are called for.

Many of the tools (probably half) are not handled by either of the methods previously referred to. To illustrate, we will assume that a drill jig and a drill are required. The part number on which the jig is to be used would be given and the drill would be called for by simply giving the name and size.

Sets of Tools for Tapping Operations—The tools used for tapping operations are commonly kept in sets and are given in exchange for one check, the same as a single tool. A typical set of tools of this kind is illustrated in Fig. 17, which shows the form of "tap block" used by the Brown & Sharpe Mfg. Co. These tap blocks equipped with tools for tapping holes of all sizes are kept in the tool supply rooms. They contain a tap drill; a "size drill" for drilling a clearance hole; a set of three taps; a counterbore to enlarge the hole, if desired, from the tap size to the body size of a screw; a counterbore for the screw head; a gage showing to what depth the screw head counterbore should be sunk; and a tap wrench. If a workman desires to drill and tap holes of a certain size, he asks for a tap block corresponding to that size, which is delivered in exchange for one check.

Portable Cabinets for Sets of Tools—The portable cabinet or cupboard of the form shown in Fig. 16 is used by the Brown & Sharpe Mfg. Co. for delivering tools in sets. The particular cabinet shown in the illustration contains the jig for a 10-inch spiral head and the necessary cutting tools, such as drills, reamers, etc. This cabinet is mounted on casters so that it can easily be rolled along the shop floor to whatever machine is to do the work. The jig is kept in the bottom part of the cabinet and is on a platform that runs on a track, so that when the door is lowered, the jig can be pulled out easily, after which it is hoisted from the platform and placed on the table of the machine. The upper section of the cabinet, which is shown with the door open, contains all the drills, counterbores, reamers, etc., that are used in connection with the jig.

Storing Heavy Sets of Tools on Skids—Sets of tools for certain machining operations are kept together in boxes in the shops of the T. B. Wood's Sons Co., Chambersburg, Pa., and the larger and heavier sets are placed on skids when not in use so that an elevating-platform type of truck can be pushed under the tool box when it is to be moved. The boxes rest on a platform which has skids on each side that are high enough to permit rolling the truck beneath the platform. A view of the storage place for these tool boxes is shown in Fig. 20, which also shows a truck in position beneath one of the boxes. The lighter boxes are placed on shelves.

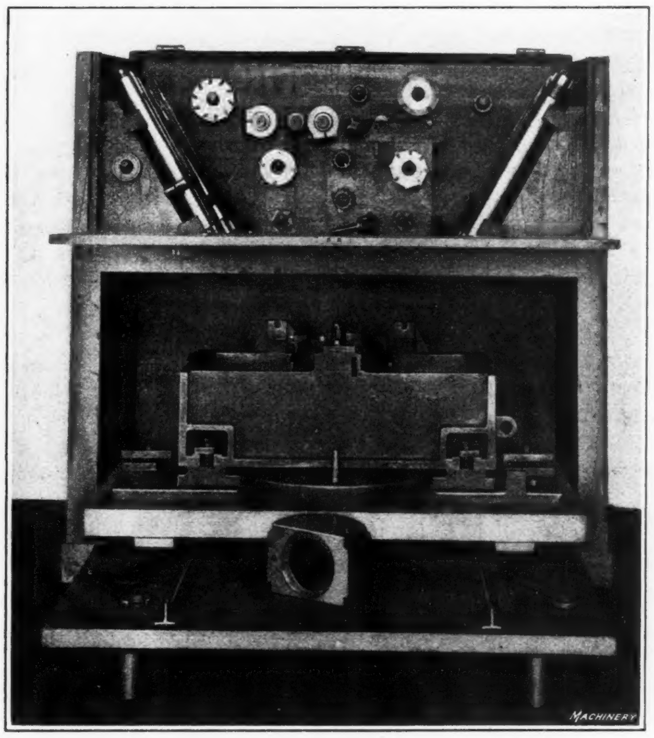


Fig. 16. Portable Cabinet containing Jig and the Necessary Cutting Tools

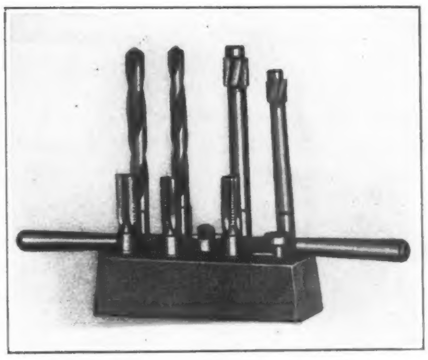


Fig. 17. Block containing Set of Tools for Drilling, Counterboring and Tapping

Tool Lists Stamped on Jigs and Fixtures—The record of the small tools used with jigs and fixtures, such as drills, reamers, milling cutters, etc., is generally on a blueprint or separate list of operations, for the guidance of the foremen or to enable the tools to be selected readily by the attendant in the supply room. At the Newark works of the Westinghouse Electric & Mfg. Co., all jigs or fixtures have stamped on them the sizes or names of whatever small tool equipment may be required and this practice has been adopted in various other plants. For instance, if a jig is used for drilling a number of different size holes, the diameter of the drill for each hole is either given directly or is indicated by a number or letter, in accordance with the different methods of indicating commercial twist drill sizes. The size of each drill is marked near the hole in the jig to which the drill belongs. If a jig is needed for drilling a certain part, the employe gives the item or part number and the tool number, which may be obtained from the blueprint. A card index file in the tool supply room shows where this particular jig is located. When the jig is obtained, drills of the different sizes stamped upon it are collected and any other tools, such as counterbores, reamers, etc., that may be included in the list. With this method, the jig or fixture itself serves as a permanent record of all the small tools required.

Storing Special Tools Separately instead of in Permanent Sets—The practice of keeping special tools permanently in sets for duplicate manufacturing operations, is not followed in some shops, especially when the work is diversified instead of being confined to the manufacture of a standardized product. At the works of the American Machine & Foundry Co., where a variety of work is done, the tools for different series of operations are stored separately in whatever part of the tool supply room each type of tool belongs. This method is followed regardless of whether the tool is special or a standard commercial type. For instance, a special reamer which may have been intended primarily for use with a certain jig is not kept with that jig, but with other reamers, because, even though the reamer is special, it may, in many cases, be used for other parts that are designed later; therefore, the special reamer, tap, or other tool, is not regarded as a special type in the sense that it is to be used exclusively for any one part. The prompt delivery of tools to each machine is insured by the following system: Each machine manufactured by the company is given a symbol and all the parts of this machine have numbers assigned to them. The foremen of the departments receive cards for the different parts which they are required to produce. These cards are marked with the machine symbol and the part number, and give a complete list of the tools needed for machining each part. To illustrate the method, assume that a drilling machine will soon be ready for drilling part No. 1726. Before the machine has finished the work on which it has been employed, the department foreman refers to the card file and removes the card bearing the part number 1726. This card, together with the blueprint for the job, which has the same symbol and part number on it, is taken to the tool supply room by one of the men who attends to the delivery of tools to the machine. All the tools listed on the card are then

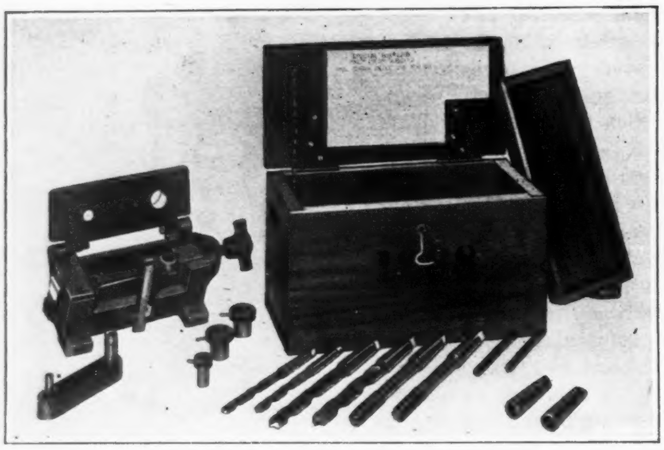


Fig. 18. Set of Tools and Box in which they are sent to Manufacturing Department

collected by the man in the supply room so that they are ready for use when needed and there is no delay at the machine. If a special tool like a drill jig is required, it can be located readily in the storage rack by the jig number on the card.

Tools that are to be used exclusively for one operation are marked with a tag. For instance, a reamer which must be kept to a certain diameter within close limits has a tag tied to it which indicates that it is not for general use.

Sets of Tools Kept by Workmen

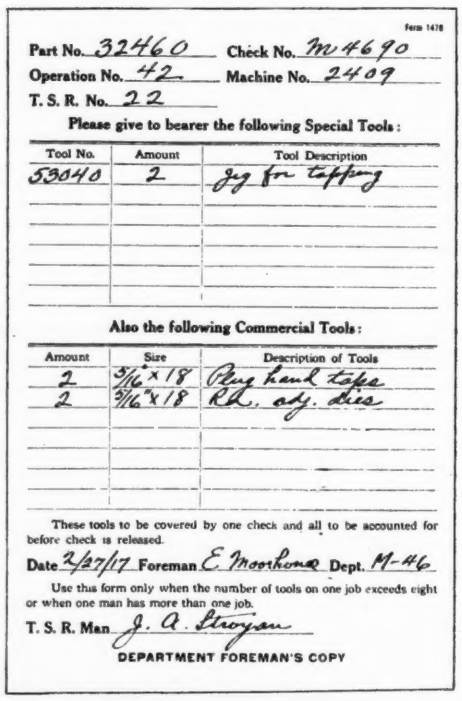
In every shop there are employes who use certain tools daily, but these tools are of the class usually furnished by the company. If they were kept in the tool supply room it would be necessary in many cases to obtain them every morning, which would mean loss of time. In many shops it is the practice to give out sets of tools of the class needed continually and these are kept by the employe permanently or until they need to be replaced. A record of the tools that are given out is kept in the tool supply room and when a man leaves the employ of a company the stock of tools he returns must agree with the record, which is modified from time to time to suit any changes which have been made during the period of employment. Such tools as cold chisels, files and file cards, scrapers, bench brushes, oil-cans, etc., are commonly issued in this way. The number of tool checks originally given to each employe is usually marked on his card and if for any reason this number should be either increased or decreased, the number on the card is changed accordingly. When a man leaves the employ of the company if the number of checks turned in to the supply room does not agree with the number on the record card, an investigation is made and the lost checks accounted for, if possible, before the employe is paid. If the missing checks are found in the tool racks, thus indicating that the employe still has tools in his possession, the cost of these tools, or some part of the cost, may be charged against him.

The method adopted by one manufacturer is to provide a printed list of tools which may be kept permanently by employes. Each foreman has a conductor's punch and the shape of the perforation serves to identify the foremen of different departments. Before tools are issued to a new employe, a punch mark must be made by the foreman in the space provided on the card opposite each tool which may be needed by that particular workman; if more than one of the tools is required, the number is marked on the card. This tool list is given to the tool-room attendant in exchange for the tools and is kept as a permanent record so that if the man should leave the employ of the company the card shows what tools should be returned to the tool supply room. Tools that are worn out, such as files, are exchanged for new ones, which does not interfere with the record on the card.

Identification of Special Tools

When an employe calls for a tool at a tool supply room, the tool may be identified either by name or in some other way, the practice varying in different shops. The necessity for a systematic method of identifying the tools needed for various operations depends to some extent upon the class of work manufactured and the extent to which special tool equipment is needed. Standard commercial tools such as reamers, drills, and taps, may readily be identified by the name and size, but the use of names for special tools would, in many instances, cause confusion and mistakes and result in a waste of time. For instance, if several special tools were used on some part, it might be difficult to give these tools names which would clearly distinguish one from the other, even though the men in the supply room were familiar with the various classes of tools.

Special tools may be identified either by a number given to the tool, by a number assigned to the part on which the tool is to be used, or by a part and tool number combined. If a part requires only one special tool, the part number and name of the tool might be used to identify the latter, but when several special tools are needed both part and tool numbers are preferable. In some cases the part number and the operation number are used. With the Taylor system of classification, all tools are given symbols composed of letters (with numbers added when necessary to indicate tool sizes) which indicate the type of tool and its location in the tool supply room (this system will be referred to under the heading "Tool Classification"). The number or symbols used to indicate the tool equipment may be on the blueprints or on special sheets or cards that contain a list of all the operations.



Form 1478

Part No. 32460 Check No. M 4690

Operation No. 42 Machine No. 2409

T. S. R. No. 22

Please give to bearer the following Special Tools:

Tool No.	Amount	Tool Description
53040	2	Jig for tapping

Also the following Commercial Tools:

Amount	Size	Description of Tools
2	5/16 × 18	Plug hand taps
2	5/16" × 18	Rd. adj. dies

These tools to be covered by one check and all to be accounted for before check is released.

Date 2/27/17 Foreman E. Moorhouse Dept. M-46

Use this form only when the number of tools on one job exceeds eight or when one man has more than one job.

T. S. R. Man J. A. Stroyan

DEPARTMENT FOREMAN'S COPY

Fig. 19. List showing what Special and Commercial Tools are required for Operations on a Given Part

Tool and Operation Lists Kept by Department Foremen—At the plant of the Intertype Corporation in Brooklyn, N. Y., the tools required for operations on different parts are shown by cards which are sent to the foremen. The card in each case gives the part number, the name of the part, the name and number of the assembled unit to which the smaller part belongs, the various operations in their successive order, and the tools required for these operations. These cards are kept permanently by the department foreman who refers to them in order to determine what tools are needed for different operations. For example, if part No. S-60 is to be machined, the foreman refers to this particular card in the file, finds out exactly what the different operations are and the name of the special tools, such as gages, arbors, fixtures, etc., which may be needed for the different operations. The employe who is to do the work is given the part number and the operation number, so that the tools may be located in the tool supply room. There is one of these tool supply rooms for each separate department. A card file in the tool supply room contains a card for each part that is machined in that particular department. These cards are filed consecutively by the part numbers, so that it is a simple matter to locate any of the tools by referring to this card file. For instance, if a workman calls for the tools for machining part No. U-47, operation 6, card No. U-47 is located in the file for operation 6, and on this card is found the name of the tool or tools and the shelf

number. All the tools, such as drill jigs, dies, special milling cutters, etc., have heavy cardboard tags attached to them. These tags, which are plainly visible, are marked with the part number, the name of the tool, the operation number, and also the equipment number which is used when taking an inventory of the tool stock. When the tool is located by referring to the shelf number shown on the card file, the tag is removed from the tool and, together with the employe's check, is left where the tool belongs. The check identifies the workman and the tag shows what tool is out and also exactly what operation it is used for.

Tool Symbols Based on Class of Work—The method of identifying tools such as jigs, fixtures, dies, etc., at the factory of the Ellis Adding-Typewriter Co., Newark, N. J., is by means of symbols on the tools and blueprints which are based on the general class or part of the mechanism for which the tools are used. The symbol, except in the case of special tools, is composed of a letter and number; the letter indicates the general section of the typewriter or adding mechanism to which the part belongs, and the number shows whether this part is a shaft, screw, collar, casting, drop-forging, punched part, spring, or a miscellaneous piece not belonging to the more common classes mentioned. The meaning of the symbols will be more apparent after referring to the following list of some of the letters used and the general classes of mechanism they represent: A, accumulator mechanism; B, base, frames, case, spring barrel, carriage ways; C, carriage, (non-shift parts); D, left-hand operating parts, governor; E, escapements; F, tabulating mechanism; G, tally roll and carriage return.

The different parts which the numbers represent are as follows: 0-9, shafts; 10-29, studs, pins, and screws; 30-44, collars (screw machine parts having holes); 45-49, castings; 50-74, punched parts; 75-79, drop-forgings; 80-89, springs; 90-99, miscellaneous parts not in above classification.

To illustrate the method of using these letters and numbers, assume that a symbol is required for a shaft in the accumulator mechanism. The symbol for this shaft would be composed of the letter A and some number between 0 and 9. If the part were a stud, pin, or screw for the accumulator mechanism, the letter A would be followed by some number between 10 and 29, as shown by the list previously referred to. This symbol or part number is marked both on the blueprint and on any special tool that may be required, such as a jig, fixture, or die.

The symbol or part number makes it possible to locate readily a special tool in the supply room. To illustrate, suppose a jig is required for part A8. This tool will be found in section A of the supply room, and as the tools are filed numerically in that section tool A8 can readily be located. If a tool is used for one of a series of operations, the particular operation, in each case, is shown by another number which is added to the symbol. For instance, if a die is marked E55-2, the letter E shows that it is for some part of the escapement, the number 55 indicates that it is a punched part,

Fig. 20. Sets of Tools stored in Boxes with Heavier Boxes on Skidded Platforms to facilitate Removal with Elevating-platform Type of Truck

and the figure 2 following this symbol shows that the die is used for the second operation. Similarly, the die for the preceding operation would have 1 after the symbol, and if the third or fourth operation were required, the additional dies used would be marked 3 and 4, respectively, after their classification symbols.

As it has been necessary to manufacture many special parts which differ from the standard parts of the adding typewriter, a different method of marking the blueprints and tools is used for the special pieces. The part number consists of a whole number and a decimal. The whole number is used instead of a letter to avoid confusion or interference with the regular symbols, and the decimal has the same meaning as a whole number preceded by a letter. For instance, No. 25.7 represents some kind of special shaft, whereas 25.46 would represent a special casting, since 7 comes between 0 and 9 which, according to the preceding list, are numbers assigned to shafts, and 46 is between 45 and 49 which are the casting numbers.

Cabinets for Identifying Files—When files are obtained from the tool supply room, the usual method of identifying them is by the names given to different classes of files. This method of identification frequently results in confusion and delay owing to the fact that the correct names are not always given by the employes. In some cases the man receiving the file asked for but not the kind wanted, does not like to admit that he was in error and the result is that a file is frequently used when it is not exactly what is required for the job. In order to insure prompt delivery of files of the size, form, and grade wanted, sample boards or cabinets are used in some shops. A cabinet in the tool-room of the Taft-Peirce Mfg. Co., is shown in Fig. 21. Every size and shape of file in the tool supply room is represented in this cabinet and each file is numbered so that the workmen, after determining the size and style required, can order it by number instead of using a name, or a manufacturer's number in the case of toolmakers' files. On some sample boards the name of the file is given instead of the number.

Numbers for Identifying Lathe and Planer Tools—Forged tools, such as are used for turning and planing operations, are sometimes identified by numbers to insure the delivery of a tool of the required shape. The different forms of tools are shown on a chart and each form is given a number which may be used instead of a name when an employe obtains tools from the tool supply room. In one shop where such a tool chart is used, the names of the different tools corresponding to the numbers are also given.

Check Boards for Tool Supply Rooms

When employes' checks are placed on a board in the tool supply rooms as a record of tools in use, the board usually has hooks which are numbered consecutively to correspond with the numbers given to different workmen. The board or cabinet illustrated at *A*, Fig. 22, has vertical rows of inclined slots for receiving the checks. While this cabinet is more expensive than a plain board with hooks, the design is compact and a door is provided so that the cabinet may be locked if desired. There are ten vertical rows of slots which are numbered along the top, as the illustration shows. Each horizontal row of slots is also given a number. By combining these numbers at the left-hand side of the board with those at the top, any check may readily be located. For instance, check No. 61 is placed in column 1, opposite 6 at the left-hand side of the board. In a similar manner, the number of any slot may be determined quickly. This method eliminates a confusing mass of numbers and permits placing the check slots close together so that the board requires a relatively small space. As the end view shows, the check slots are at an angle of 45 degrees, so that all checks will be retained in their respective positions. The slot should be somewhat less in depth than the diameter of the check so that the latter may easily be lifted out of the cabinet.

The check board illustrated at *B* has sixteen sides arranged as shown in the plan view. This board or cabinet is provided with hooks and will hold 1600 checks of ordinary size, when made to the dimensions given on the illustration. It is

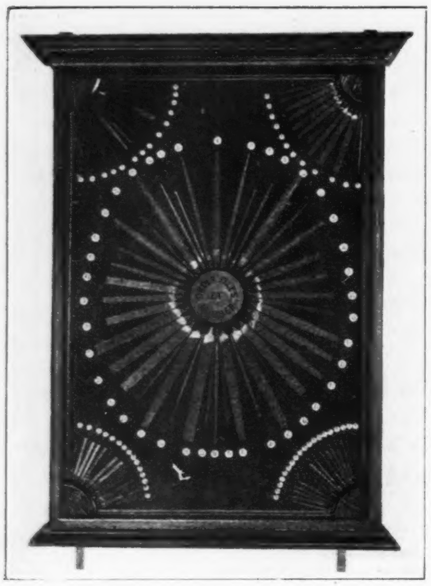


Fig. 21. Cabinet containing Sample Files which are identified at Tool Supply Room by Number instead of Name

mounted on a ball bearing so that any one of the sides may easily be turned to a convenient position for removing a check. Another check holder of the revolvable type is shown at *C*. This is simply a wooden cylinder 6 inches in diameter by 24 inches long, provided with 100 hooks. Two balls held between the cup-shaped ends of the screws shown facilitate the rotating of the cylinder. The cabinet for tool checks shown in Fig. 24 is the type used in the tool supply rooms of a large automobile factory. This cabinet is composed of several check boards which are hinged together. One board remains in a fixed position and the others are opened like the leaves of a book. All employes' checks are placed on the hooks when tools are obtained instead of being deposited in different parts of the supply room.

Grinding Turning and Planing Tools to Standard Shapes

The grinding of the class of tools used on turning and planing machines is considered an important function of the tool store-room in many plants where this system has been put into use. There are a number of reasons why machine operators are not permitted to grind those tools that are adapted to be ground by hand. In the first place, numerous experiments have proved that slight changes in the shape of a tool of the type used for turning, planing, etc., may have a decided effect on its cutting qualities and upon the length of time that the tool can be used before regrinding is necessary; therefore, it naturally follows that these tools should all be given whatever shape has proved to be most effective. In other words, tools should be standardized, especially as regards the shape of the cutting ends. The development of special tool-grinding machines and the establishment of tool-grinding departments in many shops has made it possible to have all the cutting tools uniform and ground according to approved principles.

Disadvantages of Grinding Tools by Hand—When each man is independent as to the grinding of tools, the results depend upon his experience, skill, or interest in doing things the right way. Some workmen grind their cutting tools properly and others violate every principle of tool grinding. Correct grinding is not always done even when the workman knows how different tools should be formed. Sometimes the shape of the tool is sacrificed in order to grind it quickly or easily. The way an old shopmate used to grind thread tools illustrates this point. The plan followed was to bevel the top of the face downward toward the front because the narrow point of the tool could easily be ground away. The scheme worked well and the edge was sharp, but the "negative rake" neither improved the cutting qualities of the tool nor the form of the thread cut with it. This man was an old shop foreman and knew how, but was not particular about details.

Another important reason why hand grinding by machine operators is not regarded favorably by many manufacturers is that machines are frequently idle while the tools are being ground. The amount of productive time lost in this way varies with different classes of work and also with the percentage of hustle in the operator. Some operators grind dull tools while cuts are being taken, but the extent of this practice depends upon conditions. The time taken to sharpen a tool is sometimes increased considerably because the grinding wheel is naturally more or less of a social center.

Tools that lie about machines deteriorate in many instances, their condition often depending upon the initiative of the man operating the machine; moreover, in many shops where individual sets of tools are found, there is little incentive for keeping tools in good condition. For instance, an operator who understands tool grinding may, as the result of his own efforts, secure a set of lathe or planer tools that have been carefully forged and ground, but such tools are often borrowed permanently by other workmen, so that attempting to keep up a set of tools is rather discouraging.

When tools of the class referred to are kept in the tool supply room with the other tool equipment, but the grinding of such tools is done by the machine operator, the results may depend largely upon conditions. In comparing this system with the one which provides for grinding all tools to standard shapes by means of a special grinder, instead of by individual workmen, the size of the plant and general nature of the work should be considered. In a relatively small shop where a great variety of work is done by competent machinists, the tools are often ground to suit different operations and there may be advantages in allowing the workmen to grind their own tools. Whether or not the size of the plant will warrant the installation of a special tool-grinding department for forged tools is another point to be considered, some contending that such machines should be used in small shops as well as in those of larger size.

Economy of Tool-grinding Department—In a plant employing about 2000 men it was estimated that a saving of over $5000 a year was effected by standardizing the grinding of small tools and doing this work in a special grinding department, instead of allowing the employes to grind some of the tools by hand. This method of grinding was applied not only to milling cutters, gear-cutters, reamers, drills, taps and dies, but to lathe and planer tools, chisels, scrapers, boring-bar cutters, box-tool cutters, etc. Every day the dull tools were put in boxes and sent to the grinding department. The dull tools were first replaced by sharp ones and then ground by men who were kept at this work exclusively.

Location of Tool Grinder—The grinding machine used for

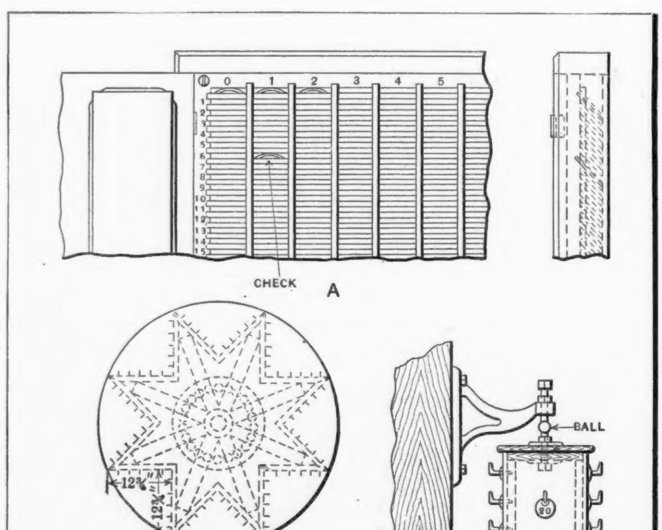


Fig. 22. Three Forms of Check Boards or Cabinets for Tool Supply Rooms

sharpening forged turning and planing tools is usually located either in the tool supply room or in a separate section of this room; it is also sometimes put in the tool-room or out in the shop. If there is not enough tool grinding to keep one man busy, the grinder is generally located where it will be convenient for the operator whose time is partly given to other work.

In some shops the grinding of forged lathe and planer tools is done in the department where the tools are forged and dressed. One method is to first forge the tools to standard shapes and then rough-grind them on a universal tool grinder before hardening; after the hardening operation the tools are finish-ground and are then stored in racks until needed in the shop. This practice of grinding forged turning and planing tools in the forging department has been adopted by the American Machine & Foundry Co. with satisfactory results. All dull tools are collected daily and one man grinds nearly all the tools of the class mentioned. The shops are equipped with grinding wheels so that the employes may grind their own tools, although this practice is not encouraged by the management. It might be assumed that hand grinding would prevail generally, but the fact is that the wheels in the shop are only used occasionally by men operating the machines because they consider that the tools ground to standard forms in a tool grinder designed for that purpose are superior to those ground by hand; consequently the wheels are used principally for sharpening tools that have been dulled slightly or for making slight changes in tools to adapt them to special operations.

Stock of Sharp Tools—When sharpened tools are issued from the tool store-room, it is advisable to have a sufficient number of each size and shape to last, say, two days before the supply is exhausted. As the dull tools are returned, they are allowed to accumulate so that a number can be ground at one setting of the machine. Tools of the same size and form should be ground successively in order to reduce the time required for adjusting the tool grinder. Fig. 23 shows the rack in which sharp tools are stored in the tool supply room of the Tabor Mfg. Co.

Maintenance of Tools

A tool store-room where tools are kept while not in use soon contains many tools that are not fit for service or that,

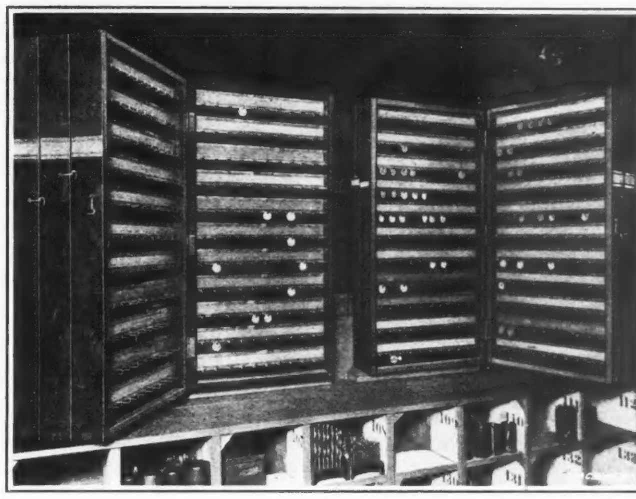


Fig. 24. Check Boards of Folding Type

at least, seriously interfere with the efficiency of manufacturing processes. One of the important functions of the tool supply department is to see that all tools are kept in good condition and that there are enough tools of each type requiring duplicates to meet the demands of the shop. This involves sharpening dull cutting tools and replacing or repairing any tools that may be partly or entirely deranged, either because of wear or breakage. In large shops, especially, it is also important to have some systematic method of investigating defective tools to determine whether or not they are worth repairing and the cause of tool breakage, so that the design or construction may be altered if it is apparent that such changes are necessary.

Fig. 23. Rack in which Forged Turning and Planing Tools are kept in Tool Supply Room

A tool maintenance system which has proved satisfactory in a large manufacturing plant is so arranged that the replacement and repair of tools is done on as systematic a basis as the regular manufacturing work. If a tool needs to be replaced because of breakage or excessive wear, the employe must first have his foreman sign a "tool release card"; the employe may then return the tool to the tool crib, where he either receives another one or the tool check, if another tool of the same kind is not needed. The release card and the damaged tool are kept together in the store-room, pending a weekly examination by an inspector who determines whether or not the tools should be repaired or discarded. In many cases, the tools become defective on account of long usage, but if it is apparent that the damage is the direct result of faulty construction or gross carelessness on the part of the user, steps are taken either to modify the design or stop the careless practice.

In case regrinding or repairs are necessary it is essential to record in the tool supply room what tools are sent out and to see that they are returned to the right place. The card or form used in such cases gives the number of the department in which the tool is used, the name of the man in charge of the tool crib, the name of the tool, the nature of the repairs or operation required, the number of the tool crib, and the order number against which the time needed for the repairs and any material that may be required is charged. A copy of this form accompanies the defective or dull tool and is kept in the tool-room where the repairing or sharpening is done, as a record of this work; a second copy is kept in the tool crib to show what tools have been sent to the tool-room, and the office also receives a copy, which is held temporarily as a reminder that the work is being done.

When files need to be replaced as a result of wear, a special order is used. The worn file is taken to the department foreman, who examines it and then makes out an order for another file, if in his judgment the old file should be replaced. On this order is written the name of the file, the size, the number of files needed, the department number, the tool crib number, the date, and the number of the employe to whom the file should be delivered. This order also bears the signature of the department foreman. The same order is used to obtain new files.

Determining Causes of Tool Breakage

The number of tools which must be replaced because of breakage can often be reduced considerably by instituting a systematic method of determining the cause of breakage in each case. A plan which has proved successful requires the use of printed forms or slips (see Fig. 25) which are given to all foremen. When an employe breaks a tool he must obtain one of these slips from the foreman in order to secure another tool or the check which has been deposited in the tool supply room. The printed slip contains a list of tools commonly used and blank spaces in which the names of other tools may be written. If a half-inch tap, for example, is broken, the size of the tap is marked in the space opposite the word "tap" on the card. The cause of breakage is indicated by a cross made by the foreman opposite whatever term on the card indicates the cause. These forms are filed back of each man's "record card" and are examined at the end of each week or month to determine what workmen are breaking the most tools and the causes for such breakage.

Check No. 45 Foreman John Smith Dept. 17

All Broken Tools Must Be Returned

Name of Tool	No.	Size	Name of Tool	No.	Size
Drill			Wrench		
Tap	1	1/2"	Milling Cutter		
Reamer					
File					
Hacksaw Blade					

Cause of Tool Breakage

____Carelessness ____Defective Construction
X Accident ____Defective Machine
____Defective Design ____Defective Jig

Fig. 25. Form used when Tools are broken by Workmen

Ideal Tool Supply Room System

The ideal tool supply room system does not exist, if by system we mean a complete plan or organization which, without modifying any of the details, may be applied universally. A system that would be ideal in one plant or machine shop might require some modification in another shop to suit local conditions. The variation may be a slight change of detail or a reduction of the entire system to a more simple form, whenever the manufacturing conditions and problems are relatively simple and do not require the more complex system necessary when a great variety of work is produced. While such changes are often essential, there is a tool supply room system which may be considered ideal in principle. Such a system would include not only the care, maintenance and accounting for all tool equipment of the classes previously referred to, but prompt delivery of such tools to various manufacturing departments before the tools are actually needed. While systematic methods of issuing tools and of maintaining them in good condition are common, the tool supply rooms of a great many machine shops are either partly or entirely independent of the manufacturing department, instead of being so interwoven with the entire system of shop management that they are controlled the same as any other department. If turning, planing and milling operations are necessary in manufacturing a certain machine, the departments doing the work will be so controlled in a well organized shop that they will act in unison, so that the maximum output of the finished product may be obtained. Inasmuch as the efficiency of any department or of an entire plant may be affected considerably by the condition of the small tool equipment, it is also important that the tool supply room be controlled with reference to the work of manufacturing, instead of placing this department in the same class as a safety deposit vault and regarding it merely as a place of storage. If a certain machine will soon complete a job, considerable delay may be avoided if the tools for the next successive job are collected in advance and placed at the machine. It is evident, however, that these tools will be useless to the machine operator unless the parts to be worked upon are also at the machine, together with the necessary blueprints and whatever additional instruction regarding the sequence of operations, etc., may be necessary; therefore, it is apparent that there should be some form of centralized control to insure prompt delivery not only of tools but of raw material, such as castings, forgings or bar stock. Naturally the details of any special system will be subject to more or less variation and may be affected by such conditions as the arrangement of the shop or factory and the uniformity or diversity of the product.

Tool Supply Room System under Scientific Management

The method of controlling the delivery and maintenance of tools adopted by the Tabor Mfg. Co. of Philadelphia will be described as a practical example of a system based on the principle that all the departments of a manufacturing plant should be so closely allied that they are like the different parts of a machine which move in perfect unison and accomplish results by concerted action. The control of the entire plant is centralized so that every department, including the

Fig. 26. Bulletin Board of Tabor Mfg. Co. for controlling Manufacturing Operations and Delivery of Tools

tool supply room, is governed with reference to the work of the entire manufacturing organization. The planning department decides how and when work should be done and governs the operations on every machine as well as the work of the assembling department; in addition, the planning department specifies the time in which each operation should be completed, and provides for supplying the necessary tools and materials in advance so that all delay is avoided. The foreman has nothing to do with the kind of work done on different machines nor with the methods of machining or assembling parts.

Before referring to the tool supply room system, a general outline of the methods of utilizing and controlling these various departments will be given. After a machine is designed it is divided into general groups which can be assembled as units, the aim being to so plan all work that the various parts of a machine may be finished in a successive order which conforms to the natural and most direct way in which the machine would be built. The successive order of all operations, as well as the tools and machines to be used, is determined beforehand, and the exact methods of procedure are outlined in detail so that all parts not only conform in size and shape to the approved design, but all work is done in the manner prescribed. A route chart is first made up which shows graphically every step in the building of a machine. This chart may be compared to a river and its tributaries, the main river representing the complete machine, and the tributaries the different units and parts which, when united, form the machine. Every operation and tool is listed and these lists are so arranged that the parts which form units and the different units which make up main groups are merged together graphically on the chart just as they would be made and assembled if all the work were done in a systematic and orderly manner from start to finish. In addition to this route chart, there are smaller route sheets for the different parts which also show what operations are required and their successive order. On these route sheets there is a record of all work which must precede the manufacturing operations, such as making the necessary detail drawings or special tools that may be required, ordering the material, recording the delivery of material, etc.

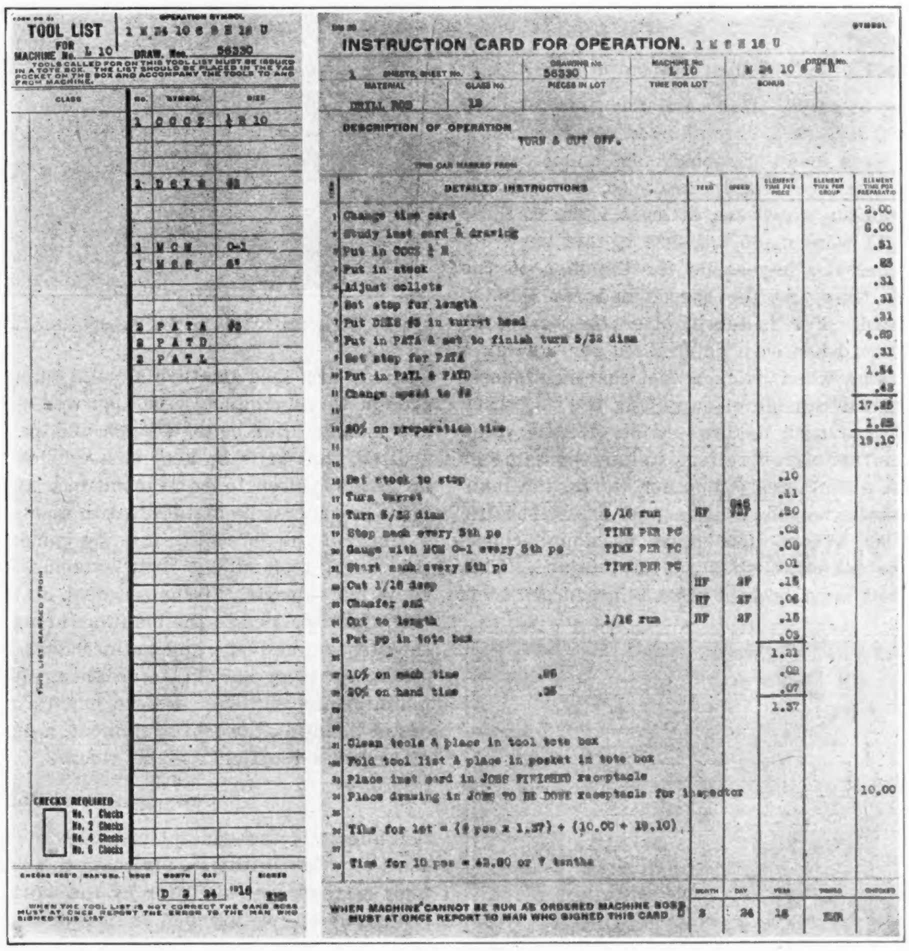


Fig. 27. List of Tools and Instruction Card for Machining Operation

When all the material and tools are ready, the work of manufacture may begin, but the order in which machines and parts of different machines are built is also governed systematically and in accordance with their relative importance. The route chart previously mentioned may not be needed for minor manufacturing operations, in which case there is only a route sheet. An operation order or slip is made out in triplicate for each job. These three slips are of different colors, which indicate where each slip belongs when they are transferred, as described later. On each order there is a special symbol, the letters of which indicate the exact nature of the operation. The machine number, the drawing number, the number of pieces required, the amount of bonus, and the time within which the work must be finished to earn the bonus, are also given on each operation order.

Bulletin Board Controlling Manufacturing Operations and Delivery of Tools

In the planning department there is a large bulletin board (see Fig. 26) containing three pairs of hooks for each machine, vise or other working places in the various departments. A symbol shows which machine, vise, etc., each set of hooks represents. The three duplicate operation orders are first placed together on the lower pair of hooks to show that the work represented by these slips is to be done. The operation orders are perforated so that they may readily be placed over the hooks. We shall assume that the operation order is for a casting which is to be planed. Before the planer on which the work is to be done is ready for it, an order is issued to move the casting from the place of storage to the machine. When the casting or any other material required has been placed near the machine (suitable storage racks or spaces are provided), the operation orders are transferred to the set of hooks marked "jobs at machine ready to be done." When the work is started, one slip is placed on the hooks marked "job on machine." This slip is left on the bulletin board in the planning department, and, as other slips are made out for each job passing through the shop, a thorough knowledge of working conditions throughout the entire plant may be obtained by studying the board and noting the location and number of the various operation orders. One of three order slips previously referred to is transferred to a separate bulletin board in the planning department to show that the list of tools and the card of instruction for that particular job should be transferred from the file to the machine or wherever the work is to be done. The third operation order is placed on a bulletin board (see Fig. 28) in whatever department is to do the work. This bulletin board shows the department foreman or "gang boss" what operations have been assigned to each machine, bench vise or other working place, and the order in which they are to be completed. It is the duty of the foreman to see that each man has whatever tools may be needed from the tool supply room for at least three jobs ahead of the one on which the man is working at the time, or more than three if the total time for three jobs requires less than three hours. The order in which the various parts are to be machined is shown by the relative positions of small index slips seen at

the left-hand side of the bulletin board shown in Fig. 28. These slips are numbered in accordance with the numbered positions of the operation orders on the board, and, as previously mentioned, the sequence in which work is done is regulated entirely by the planning department in accordance with the class of work and its importance.

Up to this point the work has been controlled entirely by the planning department which has attended to ordering and delivering the necessary material and has specified just how and where the work is to be done. Each operation order on the shop bulletin board shows the number of the machine, vise or other working place to which the work has been assigned. The tool list indicates what auxiliary tool equipment is to be used, the different tools being indicated by symbols which will be explained later. The instruction card contains not only detailed instructions regarding the exact method of doing the work, but also specifies the time for each of the elements which make up the complete operation and gives the speed and feed to be used whenever machine work is to be done. A sample tool list and also an instruction card are shown in Fig. 27.

Importance of Establishing Standards

The data pertaining to speeds, feeds and the time for each element in the work represent a vast number of experiments and tests which have been made previously and under certain standard conditions; therefore it is necessary for the management to maintain standards which are, at least, equal to those existing when the tests were made, because if this were not done, it would obviously be impossible for the men in the shop to duplicate the time and the speeds and feeds listed on the instruction card. For instance, after the best combination of speed and feed has been determined for turning a given material in a lathe when using a tool that is properly ground and a driving belt capable of supplying the necessary power, it is apparent that such data would be of little value as a guide for similar turning operations unless the same or better conditions were maintained. In other words, the management assumes certain responsibilities and prescribes the exact conditions under which work must be done; consequently standards must be established and maintained. This means that cutting tools must be kept sharp, that forged tools

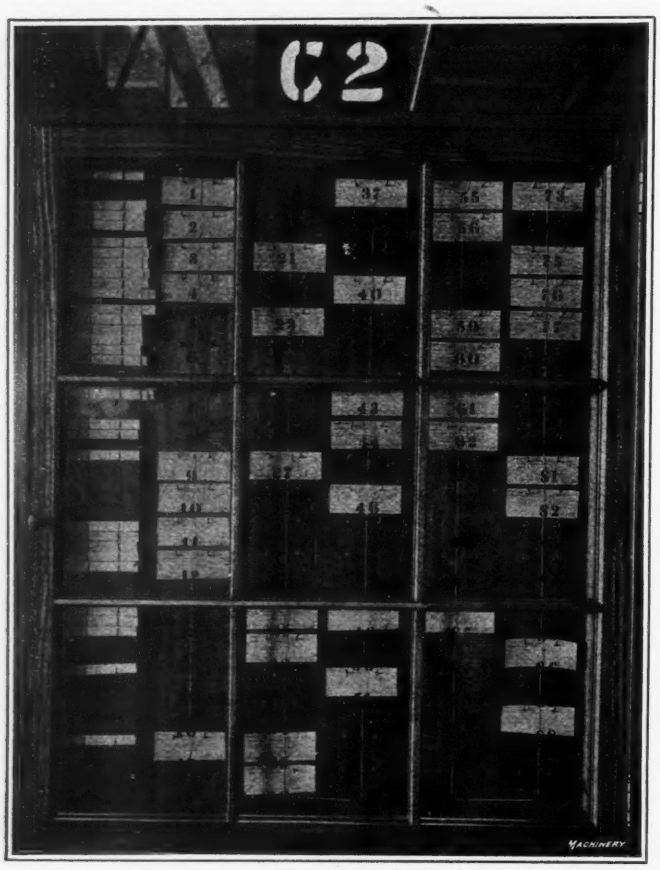


Fig. 28. Shop Bulletin Board which shows Department Foreman what Work is to be done

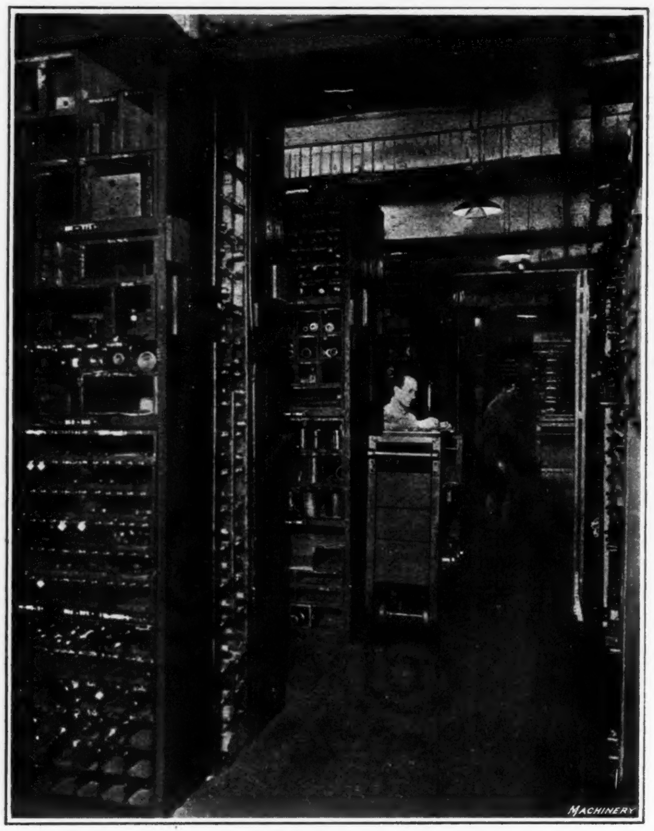


Fig. 29. View in Tool Supply Room of Tabor Mfg. Co.

such as are used on turning and planing machines must be ground in accordance with approved principles and to standard shapes, that bolts, clamps and packing blocks be standardized, that belts be kept at a tension which will enable the necessary power to be transmitted, and that the tool equipment in general be maintained in good condition.

Much of the foregoing may be considered irrelevant to the subject of tool supply room systems, but what follows will show how closely this department at the plant of the Tabor Mfg. Co. is related to the manufacturing departments, and how the storage, delivery and maintenance of tools are done in a systematic way and in accordance with the demands of the planning department. Before explaining in detail the methods of handling the tool equipment, a description of the system of tool classification will be given.

Classification of Tools

While it is the general practice to place tools of the same class together in the supply room to facilitate finding different tools as they are called for by the workmen, the classification ordinarily is not intended to include the system of identifying tools. In most shops the part number or tool number on a drawing or list of operations is simply given to a certain machine part or tool arbitrarily, but does not of itself indicate to what class the tool belongs.

With the system of tool classification devised by F. W. Taylor and adopted by the Tabor Mfg. Co., the symbol for each tool is composed of letters, each of which indicates something definite about that particular tool. When the tool cabinet is arranged to correspond with this system of classification, it is easy for anyone to locate a tool readily in a large supply room, after a brief explanation of the system, due to the fact that the location of any tool depends on the system and not upon the memory of the man in the supply room. This system is based on a general classification for all tools and the dividing of these general classes into divisions and sub-divisions, down to a tool of a certain type, form and size. For instance, the symbol might be composed of letters which show that the tool is used for turning, has a round nose or cutting end, and is bent to the left. A number added to this combination of letters would show that the tool was made of stock of a certain width. The general classification is as follows:

A—Miscellaneous tools, not elsewhere classified.

B—Bending tools. All tools for producing changes in shape by bending, folding, spinning, etc.

C—Clamps and holding devices of all kinds, including bolts and screws.

D—Drilling and boring tools. Tools that remove metal from the interior, such as drills, boring-bars, cutters, and all appliances relating to them, and lathe boring tools, etc.

E—Edge tools. Edge tools for working wood, and tools for working plastic materials, such as clay, molding sand, putty, etc.

F—Heating tools. All kinds of tools used for heating, lighting, melting and molding, oil tempering, annealing, drying, cooking, etc.

H—Hammers and all tools that work by striking or being struck, such as sledges, tups, etc., chisels, sets, flatters, etc.

L—Transportation tools. All tools used in moving materials from one place to another, such as buckets, boxes, etc., trucks, shovels, wheelbarrows, bogies, brooms, riggers' tools, slings, chains, etc.

M—Measuring tools. All instruments of precision, weights, measures, gages, etc., electrical instruments, etc.

P—Paring tools. All tools that remove metal from the surface by cutting, except slotter and milling tools. (See class D for lathe boring tools.)

R—Milling tools. All tools for milling or sawing metal.

S—Slicing tools. All parting tools and slotter tools.

T—Templets and all instruments for duplicating work, including jigs and fixtures.

U—Abrading tools. All tools used for rubbing, scraping, filing, grinding, shearing, punching, breaking, etc.

W—Wrenches and all tools used for causing rotation.

X—Painting tools. All tools used for covering a surface with an adhesive foreign material, and any for removing same.

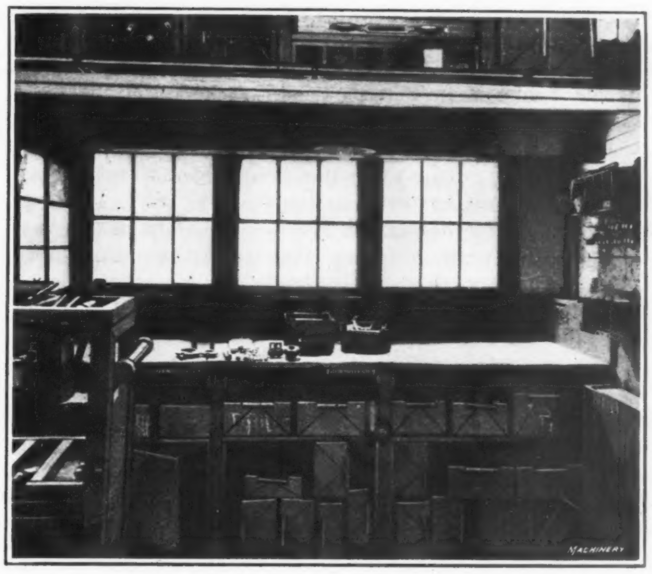


Fig. 31. Receiving Bench where Returned Tools are examined and sorted

TABLE II. KEY FOR SUB-CLASSIFYING STANDARD SHAPE CUTTING TOOLS

First Letter	Second Letter	Third Letter	Fourth Letter
Class	Shape of Cutting Edge	Sub-classification of Second Letter Shape of Nose	Straight, Bent and Hand
Paring .....P From general classification	Parting ....C Round .....R Square .....S Side ....U V-shape V	Sharp ......S Blunt ......B Broad .....W Beveled ....A	Straight ....A Straight .. right B, left C Bent 30° to right D, left E Bent 45° to right F, left G Bent 60° to right H, left J Bent 90° to right K, left L

Machinery

These general classes of tools are divided and sub-divided, and as each division and sub-division is represented by a letter, the combination of letters indicates the exact type and form of tool, although the man in the shop or tool supply room does not need to know the meaning of the various symbols because the list of tools previously mentioned insures the delivery of the proper tool equipment. The man in the tool supply room, however, should understand the system of classification so that he may readily locate any tool by means of the symbol. In connection with this system there is a record in the form of a loose-leaf book which contains symbols for the general classes of tools, as well as all sub-classes. This book is not needed for locating tools in the supply room, but it shows what symbols should be given to a new tool and enables a tool, the symbol of which is unknown, to be located if the name is given.

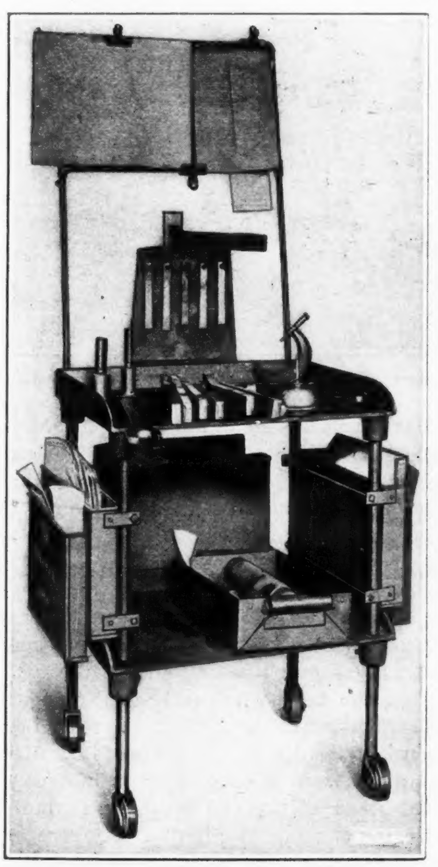


Fig. 30. Shop Tool Stand for holding Tool List, Instruction Card, Blueprints, and Sets of Tools

Table II illustrates the arrangement of the different classes of cutting tools under the general class designated as "paring tools," and by the letter P. The symbol for a turning tool having a blunt round nose and a cutting end bent 30 degrees to the left will illustrate the principle of this system of classification. Turning tools belong to class P, since they are included, as shown by the previous list, in the general group used for removing metal from a surface by cutting, except slotting and milling tools; therefore, P would be the first letter of the symbol. The next letter is found by referring to another sheet indexed under the letter P. On this sheet is a list of the different shapes of the cutting edges (see Table II), and as R represents a round nose or cutting edge, the symbol becomes PR. Each symbol on this sheet P has another sheet marked PC, PR, and so on. Sheet PR would be referred to, in this case, and it would show what letter should be added to PR to indicate that the round cutting edge is of blunt form. This letter is B, so that the symbol is now PRB. Sheet PRB is next examined to find the letter for a tool having a cutting end bent 30 degrees to the left. Letter E represents such a bend, and the symbol PRBE thus obtained is completed by adding a figure to it, which, in the case of forged tools, shows the width of the tool shank as measured on the long side. For instance, the symbol ⅞PRBE shows that the tool is a ⅞-inch blunt, round-nose tool bent 30 degrees to the left. The classification sheets show definitely that this symbol is complete, because no sheet will be found indexed under PRBE, which indicates that there is no other sub-division.

Arrangement of Tools According to Classification

The tool racks are of standard form, as previously explained under the heading "Storage Fixtures for Tool Supply Rooms." All tools are placed in the different compartments of these standardized racks in the exact order indicated by the symbol. For instance, the symbol ⅞PRBE for a turning tool would be used for locating this tool in the rack in practically the same way that the name of the tool would be determined by referring to the book of tool classifications. Symbols at the end

of each rack along the aisle illustrated in Fig. 29 show the first and last symbol included, so that a glance at these "keyboards" enables one to determine whether or not a certain symbol or tool is in that particular rack section. (One of these keyboards may be seen above the tool rack in Fig. 23.) On one of these boards will be found the symbol DBG–DDTT (up to 1 17/32"). This particular symbol shows that all tools listed in the inventory between these letters are in this rack. For example, tools having the symbol DCBG are in this rack, because DCBG comes between DBG–DDTT, according to the alphabetical order; a symbol like DDTS would also be included in this rack, because S precedes the last letter T of the symbol DDTT.

Each twenty-four-inch unit or compartment of a rack also has a symbol which serves the same purpose for this department as the keyboard previously mentioned does for the entire rack. Thus, if the symbol DDTT is over a twenty-four inch unit, it shows that only tools of this classification are in that particular department, although there may be different sizes of these tools, as in the case of drills, reamers, etc. If there were two symbols over a twenty-four-inch compartment, as DCBG–CFN, this would mean that all tools between DCBG and DCFN were in this twenty-four-inch section, although part of the tools included under the end symbols might, in some cases, be in the preceding or successive compartment of the tool rack. Boxes or drawers within the twenty-four-inch compartments are labeled with brass tags (painted black with letters filled in with white), each bearing the symbol and size of the tools in each box, tray or drawer. For example, a drawer marked 1" DDTT means that only one-inch taper shank twist drills are in it.

In order to locate a tool quickly when its symbol is given, it is essential to know the order in which the racks are arranged. The general classes of tools represented by various letters from A to X, according to the list previously given, are stored in the racks in alphabetical order. The tools in the general class A are followed by those in the B class, and so on. The standard twenty-four-inch compartment at the upper left-hand corner of a rack at one end of the tool supply room corresponds to the first page of a dictionary. The next rack, or the second one to the right of the first, represents the second page; the third is directly below the first, the fourth to the right of the third, and so on as shown by the order of the letters on the diagram Fig. 4. These twenty-four-inch units are read from left to right down to the eighth or last rack of a standard section. In this particular tool supply room most racks are composed of two sections, each containing eight twenty-four-inch compartments, and the second section is read like the first one, beginning at the upper left-hand corner and reading each horizontal pair of units or compartments from left to right. When the twenty-four-inch units are subdivided with boxes or drawers, these are also read from left to right, as in reading a book.

To illustrate the method of locating a tool from the symbol, we shall assume that the tool having the symbol DDTT 1" is required. (This happens to be the symbol for a one-inch taper shank twist drill, but it is not necessary to know this in order to locate the drill.) The main rack is first located by looking for the letter D the same as when locating a word in a dictionary. This leading letter D may not always locate the right rack, because more than one of the racks may have symbols beginning with D. The two symbols on the keyboard at the end of the rack containing this tool will be such that the first one precedes the tool symbol and the second one follows it, according to the alphabetical order. The rack marked "DBG–DDTT up to 1 17/32"," shows that it contains the tool DDTT 1". The symbol on the twenty-four-inch compartment containing this particular tool is next located, this serving the same purpose as the word at the top of the column in a dictionary, which shows that the word is somewhere in that particular column. The keyboard at the end of the rack indicates that symbol DDTT is not at the beginning of the rack, so that the first few sections are skipped and the heading DD is looked for, the same as de or dee would be in searching

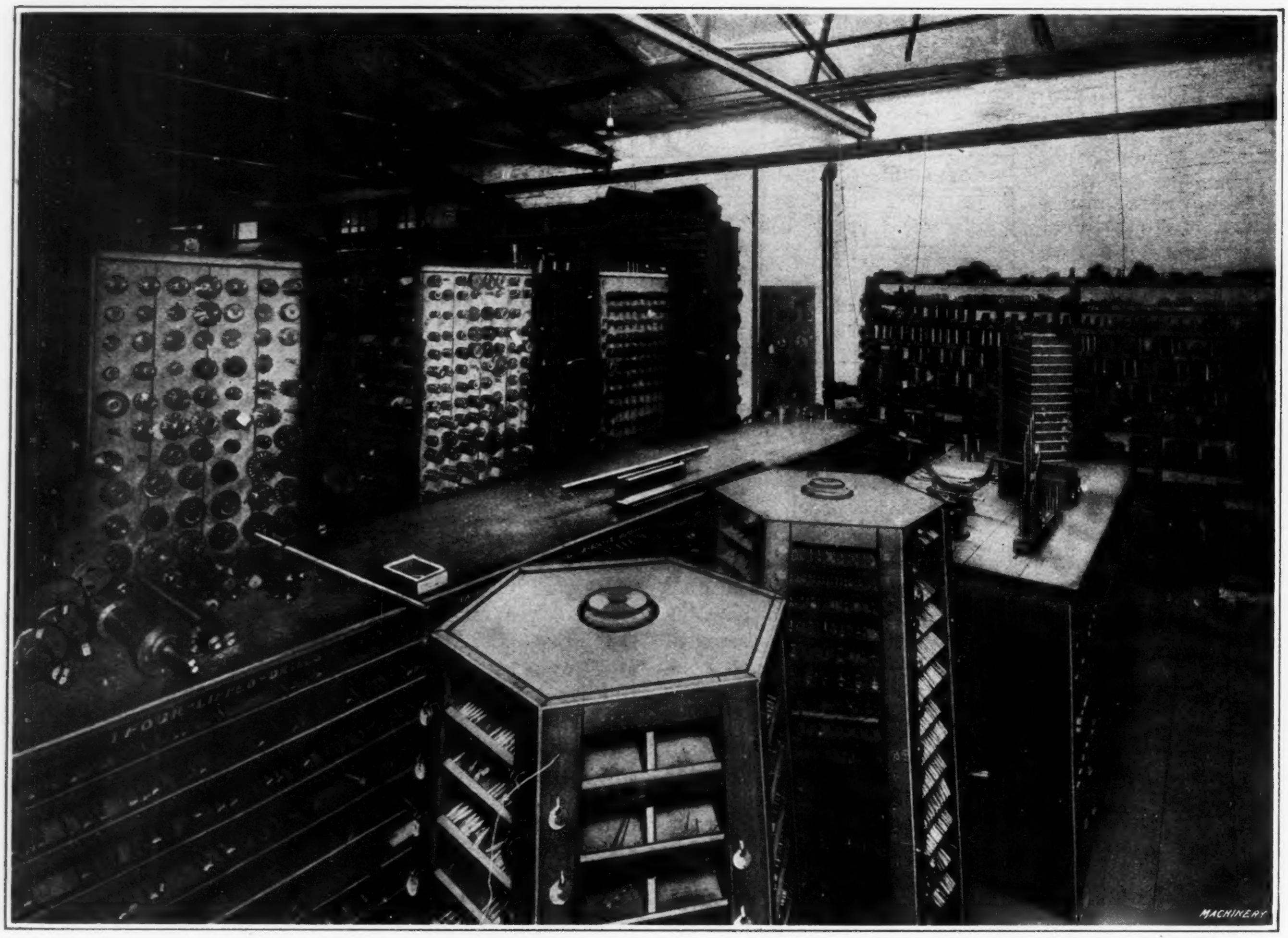


Fig. 32. View of Tool-room of Gisholt Machine Co., Madison, Wis., showing Section used for Milling Cutters, Reamers, Drills, Counterbores, Gages, etc. Note Revolving Tool Cabinets in Foreground

for the word deed in a dictionary. If the symbol DDTS is found, evidently DDTT is farther along. After finding DDTT above a twenty-four-inch division, the box, drawer or bin containing one-inch tools, in this particular case, is found. Whenever tools of one kind or type are kept in a variety of sizes they are arranged according to the size, the small tools coming first. By this plan the tools can be located without delay.

The exact method of obtaining the tools for a certain operation in the shop will be explained. We shall assume that the tools are those shown by the symbols on the tool list illustrated in Fig. 27. These tools are intended for a certain operation on machine L-10. (Incidentally these tools correspond to the ones used for the operations given on the instruction card shown in the same illustration.) The foreman or gang boss, as previously mentioned, is guided in assigning work to the men under him by the shop bulletin board in his department. (See Fig. 28.) The foreman waits until machine L-10 is two or three jobs ahead of the particular operation under consideration; the tool list for that particular operation is then sent seen in Fig. 29.) The two lower shelves contain the tote boxes in which different sets of tools are placed, and the upper shelf is for holding the tool lists, which are temporarily attached to suitable boards having spring clamps. With this arrangement several tool lists may be made up at one time, the tools called for on each being placed in a separate box. Each tool that is removed from a box, drawer or rack is replaced by a workman's check, which is placed either on a hook or in a pocket provided for that purpose, in the case of a drawer. As each tool on a list is obtained, it is checked off the list by extending a pencil line or mark along a heavy white line at the left of the column showing the number of tools required. (These tool lists are small blueprints, so that the heavy checking line seen on the tool list in Fig. 27 is white against a blue background.) This checking of the tools is done to insure the delivery of the complete set called for on the list. When a set of tools is made up, the tool list is placed in a pocket of the metal tote box and then the tools are ready to be sent out to whatever machine or other part of the shop

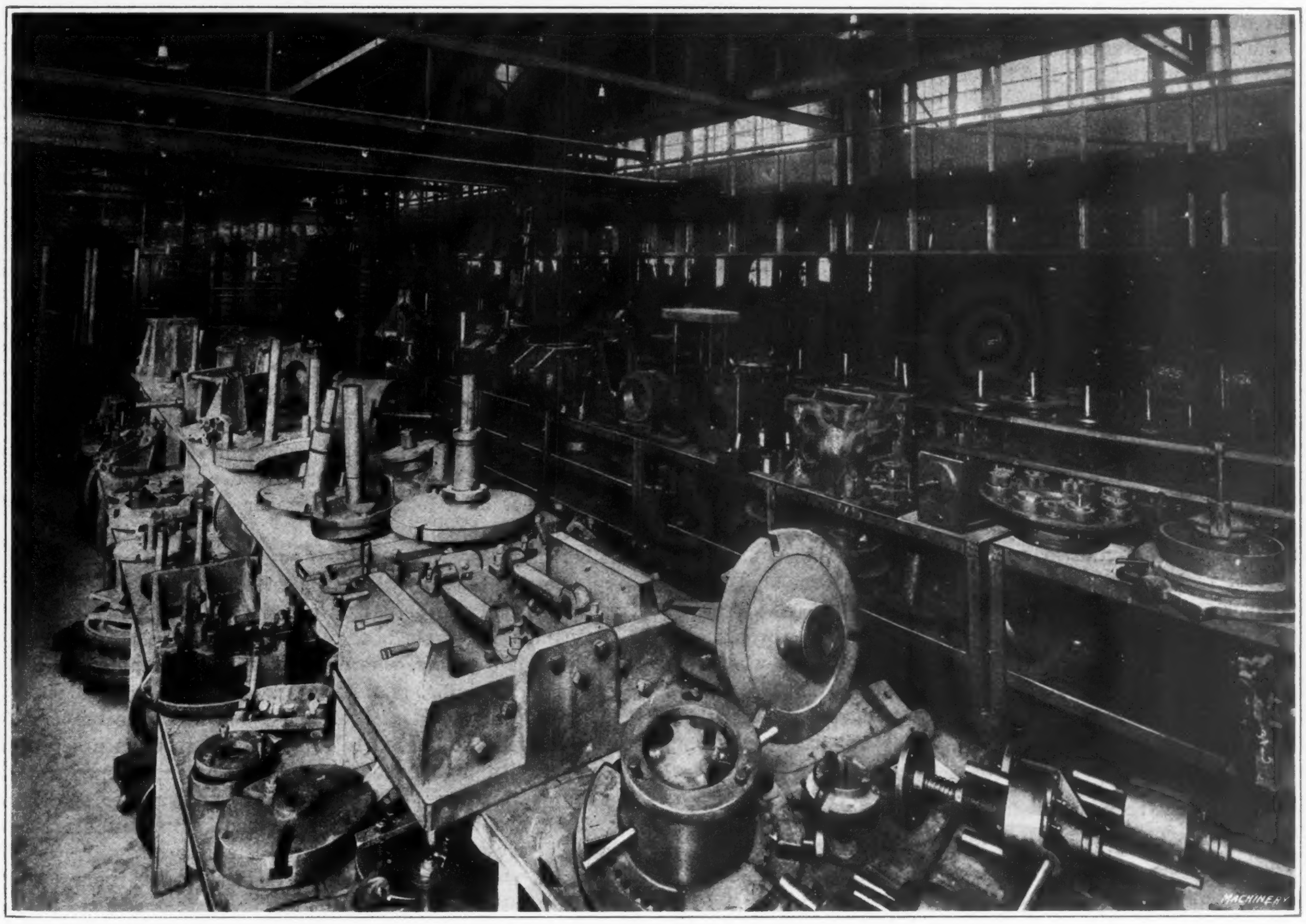


Fig. 33. Jig and Fixture Storage Section, Gisholt Machine Co. Note Hand Power Traveling Crane for lifting and carrying Heavy Fixtures

to the tool supply room by one of the boys who transfer tools.

The tool list is accompanied by enough brass checks to cover the number of tools required. These checks bear the workman's shop number, and there are four different shapes representing a corresponding number of exchange values, the same as four coins of different denominations. For example, a round check may be given in exchange for one tool, a square check for two tools, an octagonal shaped check for four tools, and a scalloped edge check for six tools. The use of these different shapes reduces the number of checks to be handled.

Method of Collecting Sets of Tools

When the tool list and checks covering the number of tools required are brought to the tool supply room, one of the attendants, using the tool list as a guide, starts to collect the tools, beginning first with those which are farthest from the delivery window. In connection with this work an "issuing truck" is used, which has three shelves. (This truck may be is marked on the tool list. (Wooden boxes fitted with compartments to protect the cutting edges are used for tools that might be injured if placed together in a metal box.

Signal Lights for Tool Delivery

Inside the tool supply room window there are three red lights arranged in a vertical row, which represent the three floors of the machine shop. Each of these lights is connected with a similar light on the first, second, and third floors, so that they can be used for attracting the attention of the boys who deliver and return tools. For instance, if a set of tools is ready for some machine on the first floor, the lower light is turned on and one of the boys comes for that set of tools.

Tool Stands for Machines

When the box containing the set of tools is brought to a machine, it is placed on the lower shelf of one of the portable tool stands illustrated in Fig. 30. The particular tool stand

shown has only one box of tools, but ordinarily there are three boxes containing the tool equipment for a corresponding number of jobs which are to follow the one on which the machine is working at the time. In this way all delay due to waiting for tools is entirely eliminated, and as soon as one job is finished, the foreman or gang boss sees that the machine is properly set up for the next operation. This tool stand is provided with pockets for holding the necessary blueprints, tool list and instruction card. When these lists and cards are brought from the planning department they are placed in the pocket marked "jobs to be done," and they are put in the pocket on the opposite side when the work is done.

Return of Tools to Place of Storage

As soon as a certain operation is completed, all of the tools, including any clamps, bolts, or blocking that may have been needed, are returned to the tool supply department with the list used in making up the tool set. Even though some of the tools are to be used on the next successive job they must first be returned to the tool supply room for inspection to show that all the tools are in the proper condition. If this plan were not followed tools might be used that were not up to the required standard. When the tool box reaches the delivery window, the tool list is removed and placed in a small compartment near the window provided for that purpose. The tools are then taken to the "receiving bench" shown in Fig. 31, where they are carefully examined so that all dull tools may be separated and placed in boxes on a shelf just beneath the receiving table. All tools that are to be sent out for sharpening are replaced by checks marked to indicate the department to which the tool has been sent. The remaining tools, after being assorted to facilitate distributing them, are placed on the "putting away truck."

The truck used when distributing tools is similar to the one employed for collecting them in sets, except that the two upper shelves are spaced or partitioned so that when tools are assorted on the table, they can be transferred to these spaces, which will keep the different types in order. As each tool is returned, the workman's check is removed from the tool rack and placed on a check ring which keeps the checks together and prevents their being lost. For each tool that is sent out to be ground or repaired, the workman's check on the tool rack is replaced by one of special form showing to which department the tool is sent.

When the tools of a set have been put away, the workman's checks and the tool list are sent back to the place where the work was done, the tool list being placed in that pocket of the tool stand representing jobs that have been finished. These lists are then removed and filed away in the planning department for future use.

Outgoing Grinding and Repair Racks

All tools that have been dulled in use and need grinding or sharpening are transferred from the receiving table to a nearby compartment marked "outgoing grinder rack." The boxes for such tools as dull drills or forged turning and planing tools are kept at the receiving table until enough tools have collected to warrant issuing an order for grinding them; they are then transferred to the "outgoing" rack and are taken from this rack by a "move man," to whatever machine or department is to do the work.

The "outgoing repair rack" serves the same purpose as the other rack referred to, except that it is for tools requiring repairs other than grinding. There is also an "incoming tool rack" for holding tools which have either been ground or repaired; new tools are also placed in this rack before being filed away in one of the regular compartments. At the time tools are ordered, the proper symbol is given to them according to their class and sub-class and this symbol is stamped on the tool. The forged tools used for turning, planing, etc., have symbols stamped on the shanks, which show the size and classification, the name of the steel, and the lot number in which the steel was received. The brand of steel is represented by letters which are an abbreviation of the trade name. These symbols are stamped in a definite place, the classification symbol being on the top of the shank near the end, the lot number on one side, and the symbol for the brand of steel on the opposite side. Incidentally, the grinding of dull tools is controlled by the planning department the same as manufacturing operations.

Summary

In order to determine what tool supply room system has been adopted most widely by manufacturers in various parts of the United States, information pertaining to the more important features has been obtained from a great many machine-building plants which differ widely in size and also as regards manufacturing conditions. This investigation showed that while details vary considerably to suit local conditions, there are certain methods of handling small tool equipment which have been employed quite generally. A brief review of the system which seems to be the most prevalent will be given.

When a man is first employed he is given a set of tools which are kept permanently. This set may include files, cold chisels, bench brushes, or whatever equipment the employe uses in connection with his daily work. A record is kept which shows what equipment should be in the possession of any employe, especially if he is about to leave.

The tools which are kept in the tool supply room are accounted for when out in the shop by means of brass checks, in 93 per cent of the shops previously referred to. Ordinarily a certain number of these checks (usually ten or fifteen) are given to each employe requiring tools, the number being recorded on the tool record previously referred to. When these checks are exchanged for tools they are usually placed where the tool belongs when not in use. In some of the shops the checks are filed on check boards, in which case a tool tag may be placed with the check to show what kind of tool is out; a double set of checks is also employed in a few shops, different methods of using them having been explained previously. In 7 per cent of the selected list of shops, some form of written receipt is given in exchange for tools.

When tools are called for at the tool supply room, special tools such as jigs, fixtures, dies, etc., are ordinarily identified by a number or a letter and number combined, which represents either a part number or a tool number; the operation number may also be included if separate operations are necessary. Sets of tools such as a jig with its drills, etc. or a milling fixture and the necessary cutters are commonly delivered to workmen in single boxes. The special tools of a set are usually kept together, whereas the standard commercial tools, such as twist drills, standard taps, reamers, and so on, are kept with other tools of their class and are collected (in advance of the time needed in some shops) to form a set when necessary. In many shops that are continually manufacturing duplicate parts, all the tools of a set, whether special or standard, are kept together permanently in suitable boxes, and a list shows what tools form a complete set.

When a shop is large enough to have a tool-room (where new tools are made) and one or more tool storage rooms, most cutting tools, such as milling cutters, reamers, drills, etc., are sharpened in the tool-room. Drills are frequently sharpened in the tool storage room even when there is a separate tool-room. In the shops of the selected list previously mentioned, 22 per cent of the drill grinding is done by the machine operators, either by hand on an ordinary grinding wheel, or by means of a drill-grinding machine. The tools for general turning and planing operations are ground by the employes using them in 84 per cent of the shops. The grinding of tools to standard shapes in universal tool grinders is done in the remaining 16 per cent of the shops. In most cases where tools are ground by hand, individual sets of tools are kept at the different machines, although the practice of keeping the main stock of tools in the supply room and issuing them in exchange for checks is quite prevalent. When tools are ground by the employe, the practice varies somewhat in different shops. For instance, in some cases sharp tools are obtained from the supply room and are ground by men until they need redressing when they are exchanged for other sharpened tools. In other shops rough tools are delivered to the workmen to be ground.

EMPLOYER'S INDEMNITY INSURANCE

BY CHESLA C. SHERLOCK [1]

Two questions arise under employer's indemnity insurance: What injuries are covered by an indemnity policy? and, What employes are covered? As to injuries, it seems that the first consideration is whether or not the employe was engaged in the usual course of his employment at the time the injury was received. Indemnity policies generally specify this requirement, so it is of prime importance to settle that question first of all.

The manner in which the courts apply this principle of law can be determined by an examination of a few specific cases. In a Missouri case, it was held that where a policy undertook to protect a wooden-box manufacturer from liability for damages on account of bodily injuries to his employes while on duty in his factory, arising in the course of operation of the business described in the policy, recovery could be had for injuries caused by the fall of an elevator even though such elevator was not mentioned in the policy. This decision was on the theory that the use of an elevator in the business described was sufficiently within the usual course of employment to come under the trade named in the policy.

In another Missouri case, the court went to the extreme when it allowed a recovery by an employer for kidney disease contracted by the employe in the handling of infected rags and paper in the usual course of her employer's business. The court held this to be an injury "accidentally suffered" within the meaning of an employer's liability policy. It is a general rule, under the workmen's compensation acts, however, that there can be no recovery for a purely occupational or industrial disease. In this case, it is presumed, the disease was not deemed to be an occupational disease so recovery was allowed.

In a Wisconsin case, where a workman employed in an iron and steel works was injured by the fall of a girder, which was being raised by an independent crew building an addition to the works, it was held to be within the terms of an indemnity policy against claims for compensation for injuries in "all operations connected with the business of iron and steel works." A Minnesota contract held that there could be no recovery, when insurance was taken on a special building, if injury resulted while additions or alterations were being made in said building, and further provided that the insurance was not to be in force until said building was fully completed and ready for occupation. The court said, however, that when an employe was injured by a defective elevator which was not fully completed, there could be a recovery under the terms of the policy contract.

The Federal courts have not been so liberal in their views. In one case, where a policy provided that the insured was to carry no explosives on the insured premises, and it was shown that the injured employe was injured by an explosion, there was no recovery. It was held in a case where an ice company sought to indemnify itself against injuries to its employes, who were engaged in cutting ice, where the company had warranted in the policy that such was their only employment, that when the employes received injuries in the fall of an ice house, there could be no recovery. Where a policy described an assured's business as that of "wholesale dry goods and stock of merchandise" and stated that the machinery used was that usual to such buildings, it was held that injuries to an employe engaged in running machinery for polishing rusted cutlery, put in the building after the issuance of the policy, were not covered by it. It has been held in two identical cases, where a policy sought to indemnify one for injuries arising through a violation of statute, that there can be no recovery on such a policy. An employer must obey the law and not seek to relieve himself of liability by insurance.

It seems to be a well settled rule that where an insurance company assumes to conduct the defense when a company is sued by an injured employe, the insurance company cannot later attempt to escape its liability on a policy claiming that the injury was incurred in violation of the terms of said policy. This reasoning is along the line that the company, knowing the full facts of the case, is estopped to later deny its liability.

Where a lumber company described its business in a policy as operating a "sawmill, planing mill, mill yards, kilns, sheds, woodsmen, and teamsters" it was held that an employe injured while boring an artesian well did not come within the terms of the policy and hence there could be no recovery. In Massachusetts the compensation law makes no reference as to the liability of companies for injuries caused outside the limits of the commonwealth. It has accordingly been held that where an insurance company agreed to indemnify a manufacturer against loss either within or without the commonwealth, but where the policy made reference to the statute, the insurance company was not liable for a death caused by injuries received outside the limits of the state. These decisions show that the injury for which recovery is allowed must occur within the scope of employment, must not be the result of failure of the employer to obey the law, and must be within the terms of the insurance policy.

There is often a marked difference of opinion as to what employes come under an indemnity policy and the importance of this proposition cannot be over-estimated. In fact, it has caused the courts as much trouble as the question of what injuries are included within the terms of the policy. It is quite generally settled that an employe or his representative has no right of action against an insurance company, when based upon a policy issued to the employer; especially is this true of one who was not employed by the insured at the time when the policy was issued.

Where the names of the employes are entered on the face of the policy at the time the policy was issued, the courts have held that there can be no recovery in favor of an employe whose name was not shown on the policy. It was proved in one case that the employe killed had been employed several times and that a portion of his earnings was applied along with the rest toward the payment of the premium on the policy. But in the face of these facts, the court held that there was no remedy for the employe whose name was not shown. Where a policy is issued to cover employes of a certain building and the building is sold and the policy transferred with it, it has been held that the policy does not cover the case of employes who were not employed at the time the policy was issued. These considerations are of marked importance to every employer of labor and no man in such circumstances can afford to neglect consideration of them.

[1] Address: 707 Youngerman Bldg., Des Moines, Iowa.

* * *

EFFECT OF AUTOMOBILE DEVELOPMENT ON THE RAILROADS

During the past two years many railroad presidents have called attention, in their annual reports, to the fact that great inroads are being made by automobiles in the passenger business. Yet the railroads have found that the development of the automobile and automobile truck has been of great financial benefit to them. According to the *Railway Age Gazette*, this development has prevented the building of many branch lines. As good roads built by the state or county serve as feeders for all railroads that they cross, many rural districts are sending, by automobiles, to railroads forty or fifty miles away as much freight and passengers as the railroads would receive if branch lines were built. This makes it possible for the railroads to spend on the betterment of the existing lines the money that would otherwise have had to be spent for the building of the branch lines, and also prevents incurring interest charges that might be as large as the profits on the lines.

* * *

The number of electric steel furnaces in the world has about doubled in the past three years, and is now nearly three hundred. Thirty furnaces have been built in Great Britain since the war began, though it is said that this nation must have cheaper electric current to make the best use of them. Fifty were constructed in the United States in 1916, while Germany's output of electric steel rose from 90,000 metric tons in 1914 to 130,000 tons in 1915.

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THE TIME HAS COME FOR EVERY AMERICAN, DUG FROM WHATEVER CLAY, CAST IN WHATEVER MOLD, TO STAND UP AND BE COUNTED, FOR OR AGAINST HIS COUNTRY.[1]

AN ECONOMIC ALLIANCE OF NATIONS[1]

"The war after the war" is a phrase in common use to represent future conditions which some business men look forward to with anxiety and which others think will not come to pass. One financial authority says:

> The competition after the war between Europe and the United States is not going to be the bitter commercial struggle that is talked of.

The control of a large share of the world's trade by a gigantic political and financial combination is foreshadowed and will doubtless be effected, not by a futile trade war, nor by the setting up of high tariff walls; but through an economic alliance of nations, by carefully organized reciprocal trading arrangements, by eliminating wasteful competition and all expense that can be saved. "The war after the war" will be team work by a group of nations—a peace campaign conducted by centralized authority. The vital necessity of working together for their own protection during the war has been so clearly evident to the Allies that they would be foolish not to profit by their experience.

The overshadowing alliance will comprise the British Empire; France, already in close working relations with Great Britain; Russia, which has been financed during the war almost entirely by Great Britain and France; and some of the smaller nations. The moment peace is declared Germany will begin to work for the Russian trade—greatly aided by her proximity to Russian markets, her intimate commercial relations with Russia, and by the powerful influence of many Russians with German blood or affiliations.

We are the farthest away from all European markets, our productive costs are the highest, our war policy has established no claim to the gratitude, not even to the respect, of any European nation. We can enter into no combination; we cannot even make a working arrangement to protect our markets under present laws, for we have no margin to bargain with. Our tariff is now the lowest (average) since 1789.

In trying to forecast the future, two years seems a safe minimum period to allow for the closing of the war and for such adjustments as must be made by the fighting nations before conditions in Europe become normal. Important changes in public sentiment may take place in that time. War has revolutionized the attitude of the English people and their representatives toward many economic questions, and it may have a similar effect here. Incredible as it seems, Congress may even divorce the tariff from politics and reframe it on business principles. The Tariff Commission and the anti-dumping amendment represent a beginning.

[1] By Alexander Luchars, Publisher of MACHINERY.

* * *

TOOL-ROOM SYSTEMS

The tool-room is the solar plexus of the manufacturing plant; disorganize the tool-room and the plant is knocked out. A good workman is judged by his tools, and by the same token one familiar with manufacturing practice can generally "size up" a shop as regards efficiency and excellence of product by an inspection of the tool-room equipment. Many of the troubles of apparently well equipped plants are due to lack of small tools and care of the tools provided. The tool-room is a comparatively new feature in the shop world, dating from the recent period when the journeyman began to use tools furnished by the master as well as those carried in his own tool-chest. In the early days the journeyman carried with him everything needed in his trade, but with the development of the manufacturing system this was no longer possible. When the master's tool-chest could no longer hold the extra equipment required by the workmen, the common tool-room came into existence. Then the shop began to furnish all the tools required on the machines, such as milling cutters, taps, drills, counterbores, reamers, saws, gages, and so on. The development of the plan of furnishing tools has been carried much further, and in some plants hammers, micrometers, try-squares and other personal tools are supplied to the men on checks, the same as the tools required for machining, fitting, testing and gaging.

The leading article in this number on tool-rooms is a review of the methods of caring for tools representative of the practice of American plants, the aim being to present a study of the typical tool-room and to include features of special merit found in a few.

* * *

GOVERNMENT DRAWINGS

Drawings furnished by the United States government to concerns undertaking the manufacture of shells, fuses and other munitions of war leave much to be desired. Those responsible for government drawings apparently have not seen fit to take a leaf from the practice of up-to-date manufacturing concerns, and their draftsmen are still making drawings of the form common in manufacturing plants thirty years ago. Instead of making detail drawings on small sheets convenient to handle and read, they still follow generally the practice of showing all details on one sheet. This means that unnecessarily large blueprints must be handled when studying details of the parts, and that each workman must be given a large blueprint, or that it must be cut up and handed out in a mutilated condition. The practice is inefficient and time-wasting to a degree; it should be avoided in manufacturing practice altogether.

Another bad practice common in government drawings is making very fine lines, which, when poorly blueprinted, are almost undecipherable. This, coupled with the fact that the draftsmen seem to have a deep-rooted aversion to drawing more lines than are absolutely necessary, makes the study of government drawings anything but a pleasant task. We recently saw drawings of the U. S. Navy 14-inch armor piercing shell, and were able only after a long study to understand its comparatively simple structure. The draftsman had shown in one view what properly should have appeared in two or three views. What valid reason there can be for practices like this is not easily comprehended. It leads to the question, how can government departments be kept up-to-date? How can they be kept from becoming fossilized and behind the times? It is a big, vital question that concerns the welfare of every citizen.

ADVANTAGES OF DIRECT SELLING

BY JAMES N. HEALD[1]

In marketing machine tools, there are both advantages and disadvantages in selling direct, and these must be weighed in connection with the kind of machine being handled when determining which method is better. If a manufacturer is building a machine like a lathe or a sensitive drilling machine, in which case there are likely to be many competing manufacturers whose products go into shops of all kinds from a machine-tool factory to a small repair or job shop—it is probable that the wisest plan would be to secure the best machine-tool dealer available in any given section and assist him as far as possible by doing good advertising work. If, on the other hand, a manufacturer is building a special machine for a particular line of work, such as a grinding machine or an automatic turret lathe, in the sale of which considerable engineering information is desirable, it is probable that selling direct through the manufacturer's own representatives will be preferable. Persons who are considering the purchase of such machines will want detailed information with regard to the output that can be expected or guaranteed, the method of tooling up the machine, the best way of chucking or holding the work, etc. They may also want a demonstrator to get them started properly in the operation of the machine.

When a manufacturer contemplates buying a lathe, drilling machine or planer, he usually feels that, if the tool appears to be properly made and of good design, his men will get out of it all that he can properly expect; but in the case of a special machine—and this is particularly true in regard to grinding machines—he wants to secure the greatest possible amount of information concerning the output that the manufacturer will guarantee, the amount of stock to be left for grinding, the best way of chucking the work, the type of wheel-head that will best cover his range of work, and so on. This information can satisfactorily be given only by the manufacturer's own representative, who has assembled these machines in the factory, run them in under belt, and has operated them for weeks or months on regular commercial work in the company's own factory. Furthermore, the manufacturer's representative in going from shop to shop, sees a great variety of work being handled on these machines and various methods and schemes in operation for handling it. He can, therefore, give the prospect he is calling upon valuable information and suggestions in connection with the work; and there is hardly anything more convincing to a person who is considering the purchase of a machine than definite and exact information as to how work of similar character is being handled in another factory and exactly what results are being secured, both as regards output and quality.

There is another aspect of this proposition. The manufacturer of a lathe, for instance, in a certain territory secures the best representative possible and then takes the business sent him by that dealer as the amount that he can properly expect from that section. In other words, the manufacturer must be content with the business that the dealer receives from his own clientele. The manufacturer of a specialty, however, cannot be satisfied with the orders that would come from the regular customers of one dealer only. Instead, he feels that he is entitled to the business that would come from all the customers in that territory who could use his machines. These, of course, are not the regular customers of any one dealer, but are divided up among all the dealers in a certain territory. In many cases, the buyers are in the habit of making most of their purchases from the dealers with whom they are on most intimate terms. Therefore, the specialty manufacturer who is pushing his business to the limit to secure everything that he thinks should come his way, wants the business that will come from all the customers in that territory and not from those that are natural traders with some one machine-tool dealer, no matter how good an organization or how satisfactory any particular dealer may be to do business with in the regular lines.

The ordinary machine-tool salesman is trying to sell thirty, or more, different tools and when asked in regard to numerous details of different machines, he must perforce refer to his catalogues and literature to seek the answer—he cannot carry all these details in his head. In the case of a special line, like grinding machines, should the prospective buyer pick up a bushing and ask one of these salesmen how many he will guarantee to grind per hour, how much stock should be left for grinding, and whether this or that operation should be done first, about all the salesman can say is that he knows "it is a mighty fine machine," and that he will take up the matter with the manufacturer and will let the buyer know as soon as he can hear from the factory. When the machine-tool builder is selling direct, his representative can answer such questions promptly because he has been in the factory and has seen the machine built; he has taken it apart and has put it together; he has been in other shops where work just like this is being done and, perhaps, has ground similar pieces in his own factory before going on the road. He can therefore give the customer information regarding the machine, its operation, and its output that is absolutely convincing; and because in the case of grinding machines a great amount of information is needed among the trade, this knowledge of the manufacturer's representative is always exceedingly welcome.

The manufacturer's representative, as he is passing along, will often see work lying on the floor of the shop that ought to be put on a grinding machine instead of being finished as it is, and oftentimes his suggestions lead to a sale of machines for work that the customer or his superintendent had never thought of finishing in this manner, and which proves to be a most economical change in manufacturing methods.

The manufacturer's representative is always looking for points in connection with the sale of grinding machines and grinding machines only, while the ordinary machine-tool salesman is likely, upon meeting the purchasing agent or the superintendent, after passing a few remarks about the weather, to ask, "What is on your mind today?" and so far as the salesman is concerned, it does not matter whether it is arbor presses or milling machines. He is willing to talk about either and will finish his call and go away perfectly satisfied without having mentioned grinding machines at any time during his call. Therefore, the method of direct selling has a good many of the advantages that we get in a single-purpose machine tool, so far as efficiency in that particular direction is concerned.

It may be argued that the manufacturer can send out a representative to work in connection with the dealer and his salesmen, and in that way the advantages of both systems can be secured. This plan, however, does not work out satisfactorily, as experience has proved. In the first place, the writer repeatedly has seen the condition develop of the dealer's salesman giving the customer insufficient and incorrect information rather than asking the manufacturer's representative to go with him to see the person making the inquiry. The dealer's salesman seems to think that it is a reflection upon his selling ability if he asks the manufacturer's representative to go with him and assist in giving the information wanted. He will run the risk of losing the order on account of insufficient information rather than to ask assistance from the manufacturer's representative. In many cases this is not knowingly done, because the salesman does not appreciate how incomplete the information really is that he furnishes.

Another difficulty in this scheme of working together develops in this way. When the manufacturer's representative goes to a certain city, he calls at the dealer's office and inquires what he can do for him in that section. The dealer will probably tell him of some places where it would be well for him to go, but they are all among the dealer's regular customers—none among the people who regularly buy of the other dealers in that section; yet those are really the ones who need going after the most.

If however, the manufacturer's representative starts out independently to canvass the territory, street by street and shop by shop, what is the result? He will, after a time, run across a person who becomes interested in the machine. They talk over the advantages and various points, and the pros-

[1] Treasurer and General Manager, Heald Machine Co., Worcester, Mass.

pective customer becomes interested in having one of these machines in his factory. He then says, "Now what is the best price and terms you can give me?" The manufacturer's representative is then at the end of his rope; he is not supposed to quote prices and give terms; he does not know what terms that particular customer usually receives from the manufacturer's agents in that section. He may have been getting a certain period of time in the past, or the agents may insist on his paying cash, or they may require a lease before they will sell him machinery, or they may have had trouble in regard to other sales and are not anxious to sell him at all, and finally, he may be a person who has not bought machines from them before. The manufacturer's representative can only say, "I will have one of our agent's salesmen see you about the matter of terms, etc.," which is exceedingly unfortunate because the time to make a sale is when the customer is in the mood, and a day or two later when the other salesman comes around, probably alone, the prospect has changed his mind, or other questions have come up that the manufacturer's representative could answer satisfactorily, but the dealer's man cannot, and then the sale hangs fire and often falls through entirely. Therefore, the company with which the writer is associated feels that after its man has gone out and brought the prospect to the point where he is ready to place an order, the salesman might as well take the order, as for him to drop the matter at the most vital point and turn it over to another person who must be paid a commission greater than what it then costs to carry out the remainder of the deal.

Another objection to selling through a machine-tool dealer is that sometimes the customer is sore on account of having had something "put over on him" by the dealer a month or a year previous with regard to the sale of a second-hand machine, or on account of some dispute as to settlement of account, or concerning equipment that was not furnished on a machine, and does not want to buy from that dealer. Direct selling obviates this difficulty, and in many cases the customer feels that if trouble should develop with the machine, he can, perhaps, get fully as prompt service in buying direct from the manufacturer as he would if bought in a less direct manner.

With regard to the cost of direct selling, the writer would say that the company with which he is connected has found that the selling expense has been considerably less than the commission allowed the dealer for selling in the same territory. He believes, however, that the advantages of working directly among the users in any section are great enough to warrant paying more money for this service, if necessary, than the dealer's commissions would amount to, because it is difficult to measure exactly the value of work of this kind, and the general results obtained over a period of years are really the only test.

In closing it will be proper to mention one limitation of this proposition, which is, that it is not advisable to carry the direct-selling plan into effect in districts where the number of machine purchasers is small, or a great distance from the factory, such as in the South and on the Pacific Coast. In such sections it is more convenient for the manufacturer to work with the regular machine-tool dealer; but in thickly settled sections the method of direct selling, under certain conditions, seems to the writer to produce more satisfactory results, and to be more advantageous in many ways if one is manufacturing a special tool similar to those mentioned.

* * *

MACHINE HOUR RATES

BY C. C. GRAY[1]

The records of machine-tool operating expense included in the article on "Reversing Planer Motors" in the November number of MACHINERY were obtained from machines operating on entirely different work, in various sections of the shop. The widely varying cost of supervision and clerical work is due not alone to the fact that the machines were doing different work, but also to the fact that they occupied varying areas of floor space, on which basis the proportion of salaries, etc., is estimated. The following explanation of how to compute machine hour rates, as practiced by a number of companies in this country, may serve to illustrate the point.

Every shop, in addition to workmen's wages, has other expenses, such as interest and depreciation on cost of buildings and accessories; repairs and renewals to existing equipment; general operating expenses, including losses due to defective workmanship, design, and material; and salaries of supervisors, engineering staff, and clerks. These overhead charges must be included in the cost of every article manufactured. A method frequently employed is to determine, from time to time, the percentage that the total charge bears to the cost of the total or actual productive labor and then obtain the total labor charge by multiplying the actual labor cost by 1 plus the percentage to be added for overhead charge. This is an easy way to take care of overhead, but is inaccurate and does not show the relative importance of different types and sizes of machines, especially where a great variety of materials is manufactured in shops using a large number of different types and sizes of tools. Under such conditions, the percentage varies within wide limits for different kinds of work.

One of the most satisfactory methods of distribution is to set off against each machine its proportion of the total overhead charge. The portion chargeable to each depends entirely on local conditions, and thorough familiarity with the conditions is needed in order that the charges may be apportioned equitably. In a shop where only one type of article is manufactured and castings are passed directly from one machine to the next, a simple and logical plan is to divide the total overhead charge among the machines in proportion to the floor space charged to each. Such conditions, however, do not exist in the majority of shops, as usually several sizes and kinds of articles are turned out and various sizes and types of machines, differing greatly in their operating characteristics, are used. In most cases, not only must the floor space be considered, but also the time each machine is actually in operation, the nature of the work being done, and the amount of supervision and engineering attention needed. Large shops that handle different classes of materials, as a rule, are divided into departments or sections, each of which may be considered as a separate smaller factory. Thus the overhead charges against each department or section may be apportioned among its tools in proportion to the floor space occupied, proper allowance being made for special local conditions or supervision and engineering attention. In making an analysis of the method for determining the hourly overhead charges, or machine hour rates, per machine tool, it will be found that these overhead charges may be grouped into three main classes, as follows: charges against the entire factory, charges against each section or department of the factory, charges against each machine tool.

Charges against the entire factory are: fixed charges, or interest and depreciation, taxes and insurance on buildings, grounds and accessories; variable charges, or repairs and renewals on building and accessories (omitting all charges that can be set off directly to a particular section of the factory); charges against store-room and tool-room, defective design, material, or workmanship; and salaries not chargeable to a definite section, including cost of superintendence, engineering and drawing, and clerical force, including office boys and general laborers.

Charges against each section or department of the factory are: fixed charges, which include an equitable portion of the total factory fixed charge, and interest and depreciation on auxiliary apparatus located in the section; variable charges, which include a portion of the variable charges as well as similar charges belonging to the section, such as repairs and renewals, store-room and tool-room charges, defective design, material, and workmanship, lubricants, and manufacturing supplies; and salaries, including a portion of the total salaries as well as those belonging exclusively to the section; that is, formen, clerks, errand boys, laborers, crane-men, etc.

Charges against each machine tool are: a portion of the fixed charges, of the variable charges, of the salaries charge, interest on cost of machine-tool taken at 6 per cent, depreciation in value of machine-tool, and cost of power to operate tool, including lighting and crane service.

[1] Address: Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.

GAGING AND INSPECTING GEARS[1]

FIXTURES FOR TESTING PITCH, PITCH DIAMETER, TOOTH SHAPE, TOOTH THICKNESS AND CONCENTRICITY

BY DOUGLAS T. HAMILTON[2]

GEARS are inspected during the process of manufacture to determine if the shape, diameter, width, tooth forms, etc., are correct within the required tolerances, and they are also given concentricity tests. Gears in which the teeth are not concentric with the hole or are unevenly spaced are noisy, especially when they are operated at high speeds. The teeth, therefore, receive the most careful attention in the inspection department, as the efficiency of a gear under actual working conditions is governed more by the shape and accuracy of the teeth than any other one factor. In this connection, the tooth shape, pitch and pitch diameter are the three most important points to consider. In the following, attention will be directed chiefly to the testing of the teeth in spur, helical, bevel and worm gears.

Inspecting Gear Blanks

The methods of testing blanks for spur gears do not differ from those for testing many other interchangeable parts, in which plug gages, snap gages and regular micrometer calipers are used. For inspecting bevel gear blanks, these tools are employed in connection with properly shaped templets. The type of inspection tool, of course, is governed to a large extent by the character and shape of the work. An important point in machining blanks for spur gears is to have the sides finished accurately in relation to the hole, so that the arbor on which the gears are held, especially when several are mounted together, will not be sprung out of truth. A satisfactory means of testing this is to place the gear blank on an accurate arbor held on centers, and rotate it past the spindle point of a dial test indicator. In testing the shape of gears, when a bevel surface, etc., is to be produced, a templet is generally employed if great accuracy is not essential.

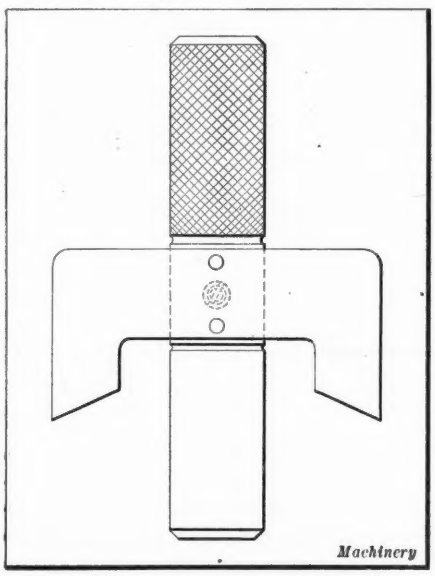


Fig. 1. Combination Plug and Templet Gage for inspecting Bevel Gear Blanks

Templets for Gear Blanks

As has been previously mentioned, spur gear blanks are inspected by regular plug and snap gages or micrometer calipers. Bevel gear blanks, on the other hand, require some form of templet for testing the relation of the angular faces to the hole and to each other. One form of templet gage for bevel gear blanks is shown in Fig. 1. Reference to this illustration will show that this gage comprises a central plug which fits in the hole in the gear blank, and a templet fitting in a notch cut in the plug. This notch is cut to the center so that the flat gaging face of the templet and the axis of the plug coincide. With this device it is possible to test the truth of the hole with relation to the angular face of the gear, and at the same time inspect the angle of the face.

A convenient form of miter gear templet is shown in Fig. 2. This is made of sheet steel, and completely encloses the gear, thus controlling both the angular face and the over-all length. In laying out this form of templet, the first step is to find the center of a circle which will touch all three sides of the isosceles triangle as shown by the dotted outline. This is a simple problem in trigonometry, as is shown by the illustration.

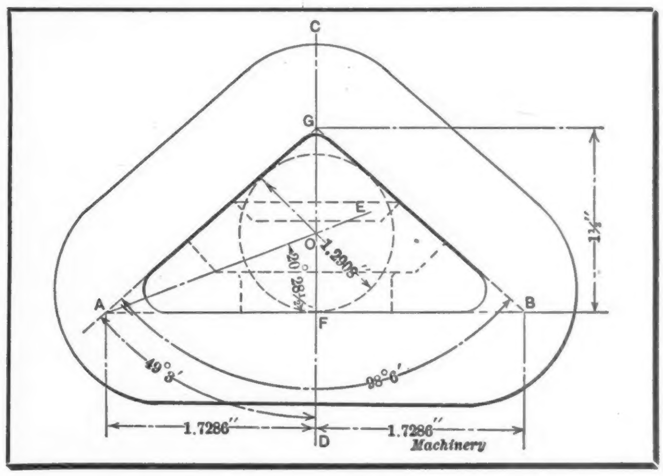


Fig. 2. Templet for inspecting Miter Gear Blanks

Bevel Protractor for Testing Bevel Gear Blanks

The ordinary bevel protractor familiar to all mechanics is commonly used for testing bevel gear blanks. A special application of this principle is shown in Fig. 3. This device consists of two hinged bases carrying sliding blocks, in which studs are held for supporting the gear blanks being tested. In addition to having regular protractor graduations for setting the gear axes to the required angle, graduations are provided for showing the longitudinal settings of the sliding blocks on the two arms. These longitudinal graduations, however, cannot be used to advantage as a measurement of the center distances of bevel gears, but by swinging the movable arm back to an included angle of 180 degrees, the device could be used for spur gears. As the angular face of a bevel or miter gear is of prime importance, two blanks could be held in this fixture and rotated together, to test for concentricity and correctness of angular face.

Gear Tooth Templets and Calipers

The simplest form of gear tooth templet is shown at *A* in Fig. 4. This is a piece of sheet steel with a slot in its lower end equal in width to the thickness of the tooth at the pitch line and of a depth equal to the height of the tooth from the pitch line. The chief objection to this templet is that it wears quickly at the sharp corners *a* and soon becomes inaccurate. *B* shows a form of templet which is used chiefly for bevel gears and is more like a scriber than a templet. It is used to scribe

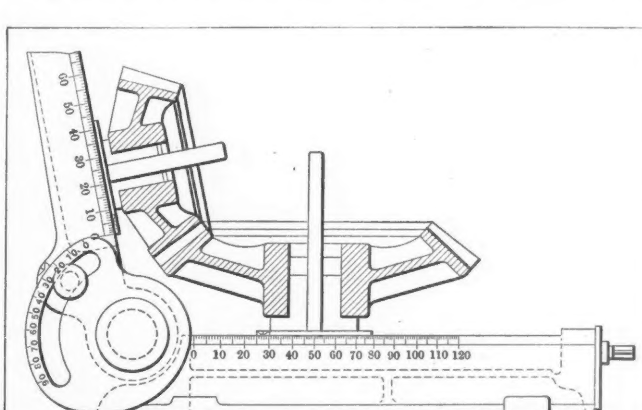


Fig. 3. Protractor for testing Truth of Bevel Gears

[1]For previous articles on gaging and inspecting, see "Gaging and Inspecting Threads" in the February and March, 1917, numbers of MACHINERY and articles referred to in connection with the first installment.
[2]Address: Fellows Gear Shaper Co., Springfield, Vt.

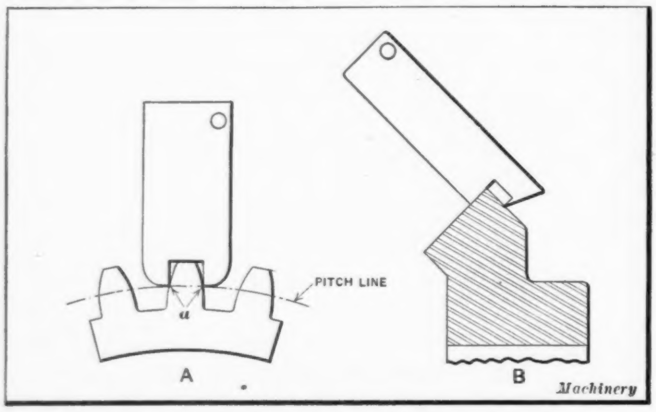


Fig. 4. Templets used in cutting Gear Teeth

a line on a gear indicating the depth to which the teeth are to be cut at the rear or large end. It is used only when a few gears of one size are to be made.

Gear Tooth Caliper

The gear tooth caliper shown in Figs. 5 and 6 is a widely used tool in the shop for measuring gear teeth, especially after cutting the first tooth. This test is especially desirable if there is any doubt about the accuracy of the blank diameter. (The outside diameter of a gear blank can be found by adding 2 to the number of teeth and dividing by the diametral pitch.) To test the tooth thickness, two trial cuts are taken for a short distance at one side of the blank until a full tooth is produced. The vernier scale of the caliper is set so that when

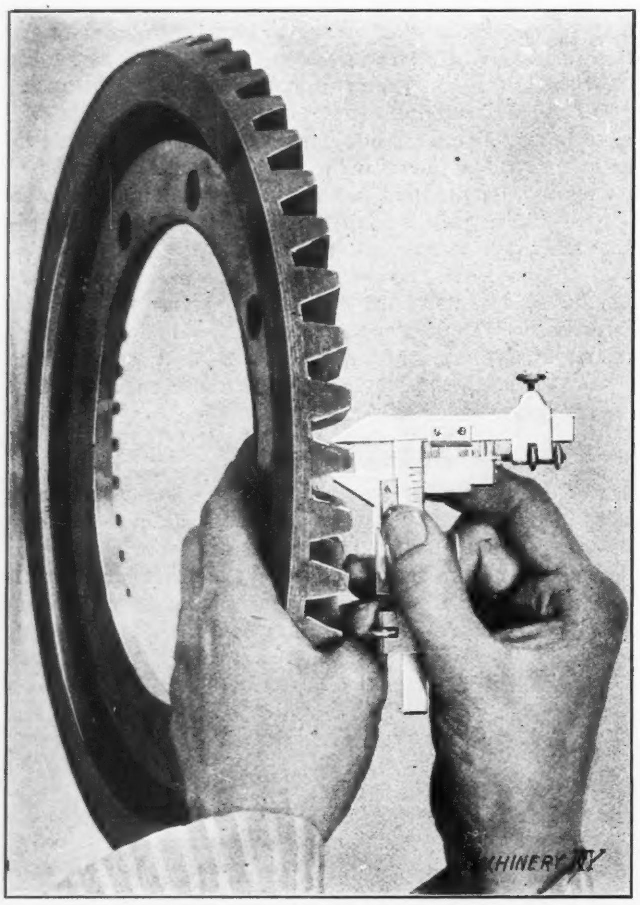


Fig. 5. Brown & Sharpe Gear Tooth Caliper in Use measuring Tooth of Bevel Ring Gear

it rests on the top of the tooth, as shown in Fig. 6, the lower ends of the caliper jaws will come to the pitch circle. The horizontal scale then shows the chordal thickness at this point. When a gear tooth is measured with this caliper, the chordal thickness T (see detail of the tooth) is obtained, and not the thickness along the pitch circle. Hence, when measuring teeth of coarse pitch, especially if the diameter of the gear is small, dimension T should be obtained. It is also necessary to find the height x of the arc and add it to the addendum S to obtain the correct height H, in order to measure the chordal thickness at the proper point on the sides of the tooth.

If α = one-half the angle subtended from center of gear by one gear tooth; N = number of teeth in gear; T = chordal thickness of tooth at pitch line; and R = pitch radius of gear; then:

$$\alpha = 90 \text{ deg.} \div N; \; T = 2R \times \sin \alpha$$

The height x of the arc equals 1 minus the cosine of angle α, multiplied by the pitch radius of the gear, or expressed as a formula, $x = R\,(1 - \cos \alpha)$. The vernier scale is therefore set to the dimension H, or x + addendum S.

Tolerances for Spur Gears

The three most important factors in a gear are the profile of the teeth, pitch diameter and center distances. The outside diameter is not so important, as there is always clearance provided at the bottom of the teeth. Tolerances should be

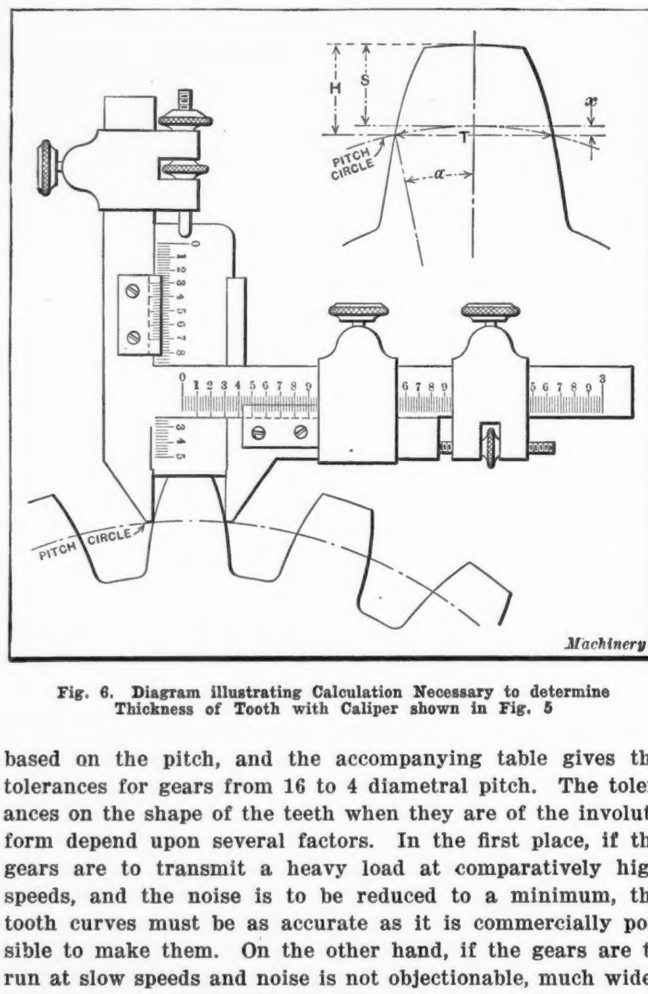


Fig. 6. Diagram illustrating Calculation Necessary to determine Thickness of Tooth with Caliper shown in Fig. 5

based on the pitch, and the accompanying table gives the tolerances for gears from 16 to 4 diametral pitch. The tolerances on the shape of the teeth when they are of the involute form depend upon several factors. In the first place, if the gears are to transmit a heavy load at comparatively high speeds, and the noise is to be reduced to a minimum, the tooth curves must be as accurate as it is commercially possible to make them. On the other hand, if the gears are to run at slow speeds and noise is not objectionable, much wider tolerances are permissible. On the average run of good gears, especially for automobile transmissions, an endeavor is made to hold the involute curve to tolerance of 0.0005 inch. The variation in tooth spacing should not exceed 0.002 inch if the best results are to be expected. Gears having ground teeth, however, are held to closer limits than this for spacing, usually 0.0005 inch. This is especially true of gears used in torpedoes.

MANUFACTURING TOLERANCES FOR SPUR GEARS

Pitch	Center Distance	Pitch Diameter	Outside Diameter Blanks,
16	± 0.002	— 0.003 to — 0.005	0.000 to — 0.005
14	± 0.003	— 0.004 to — 0.006	0.000 to — 0.005
12	± 0.0035	— 0.0045 to — 0.007	0.000 to — 0.006
10	± 0.004	— 0.005 to — 0.008	0.000 to — 0.006
8	± 0.005	— 0.006 to — 0.009	0.000 to — 0.007
6	± 0.006	— 0.007 to — 0.010	0.000 to — 0.008
5	± 0.007	— 0.008 to — 0.011	0.000 to — 0.010
4	± 0.008	— 0.009 to — 0.012	0.000 to — 0.015

Machinery

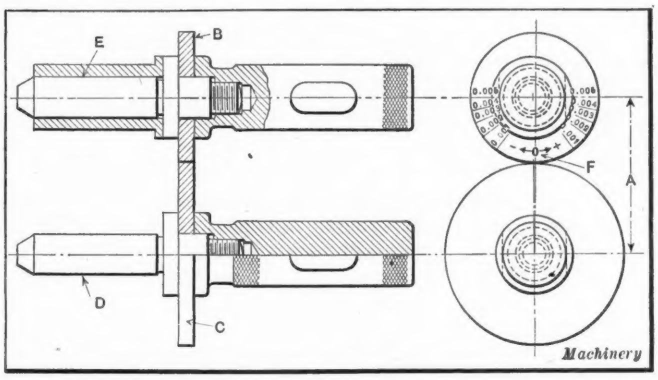


Fig. 7. Special Plug Gage for gaging Gear Center Distances

Tolerances for Bevel Gears

In mounting a bevel pinion which must run in proper mesh with a ring gear, it is essential that backlash be provided for to prevent crowding the teeth. The apex angles of the pinion and ring gear are frequently held to limits as close as 0.005 inch. For gears that are hardened, however, it is necessary in some cases to allow a greater tolerance than this to take care of warpage which causes a change of the angle of the bevel gear. When this is done it is usual to allow for a reasonable amount of backlash between the teeth, the limits varying from 0.005 to 0.007 inch, and never exceeding 0.010 inch. This means that a bevel gear must be straightened before being assembled if the warpage is in excess of the amount given; otherwise, it will be noisy in action and inefficient.

The tolerances on the teeth of bevel gears are dependent upon the uses to which the gears are to be put. Generally the tooth curves are held to within 0.002 inch and the spacing of the teeth to the same tolerance. As previously mentioned, however, when a gear is hardened, the tolerance, of necessity, must be greater than this to provide for warpage of the teeth.

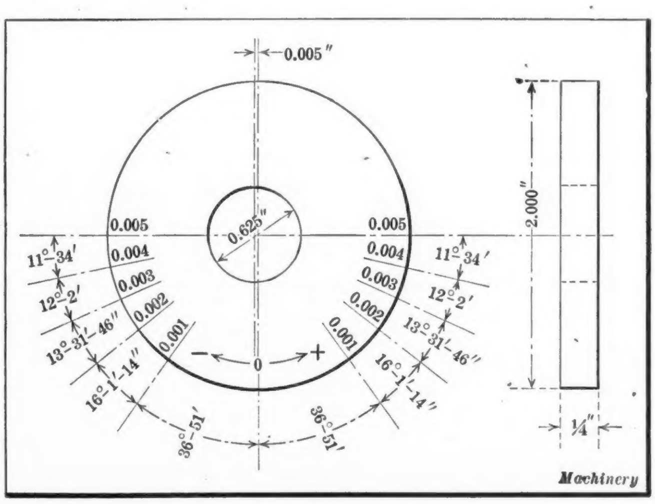


Fig. 8. Enlarged View of Graduated Disk B shown in Fig. 7

Bevel gears of the straight-tooth type, when used in automobile transmissions, are generally run in, using emery and oil to grind down any slight irregularities in the teeth due to warpage in hardening.

Testing Center Distances of Spur Gears

As has been previously mentioned, the center distances of spur gears which must run quietly is an important consideration in the cutting of gear teeth. Fig. 7 shows a simple but effective gage for testing the center distances of spur gears. The gage consists chiefly of two accurately ground collars *B* and *C*, which are held on plug gages *E* and *D*, as shown, the former being provided with bushings to suit the diameters of the holes in the gears.

To illustrate the use of this tool, we will assume that the center distance *A* is 5 inches. The collars *B* and *C* are made so that the sum of their combined radii will equal this amount. In other words, collar *B* could be 2 inches and *C* 8 inches in diameter. Referring now to Fig. 8, which shows the angular spacing for variations in the center distance of the gears, we will assume that *F* represents the zero or datum line from which the center distances are measured. It is now evident that if we turn graduated collar *B* through an angle of 36 degrees, 51 minutes in a clockwise direction, the center distance is + 0.001 inch. Similarly, if collar *B* is turned the same amount in a counter-clockwise direction, the center distance will be — 0.001 inch. If the collar is rotated through an angle of 90 degrees in either direction, the center distance will be + 0.005 inch or — 0.005 inch, depending upon the direction in which the collar is turned. By making a series of plain collars to replace collar *C*, any required center distance can be measured to very accurate limits.

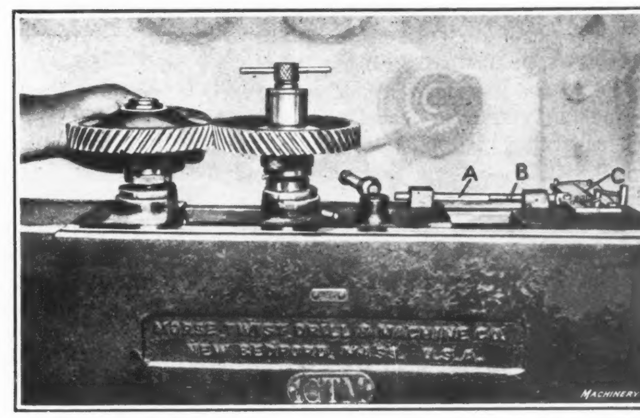


Fig. 9. Standard Fixture for testing Concentricity and Center Distances of Spur Gears

Testing Pitch Diameter and Concentricity of Spur Gears

Many interesting fixtures have been devised for testing the pitch diameter, center distance and concentricity of spur gears. A standard fixture used for this purpose which is built by the Morse Twist Drill & Machine Co., New Bedford, Mass., is shown in Fig. 9. This fixture consists principally of a base carrying one fixed and one movable slide, each slide carrying a stud on which the gears to be tested are held.

The gear held on the stud in the fixed slide is usually a carefully cut, and sometimes ground, master gear, which is brought into mesh with the gear to be tested. The movable slide carries a rod *A*, which contacts with a rod *B*, the latter operating an indicating needle *C* through a multiplying lever arrangement. When the center distance as well as the concentricity of the gear is to be tested, the movable slide is set to the required center distance by means of a vernier scale on the bed; then when the gears are rotated, any inaccuracies in either center distance or concentricity are noted on the scale over which the indicating needle moves. If it is desired to test concentricity only, no attention is paid to the vernier, and the gear to be tested is kept in contact with the master by a spring, not shown, the latter being rotated and the fluctuation of the needle noted.

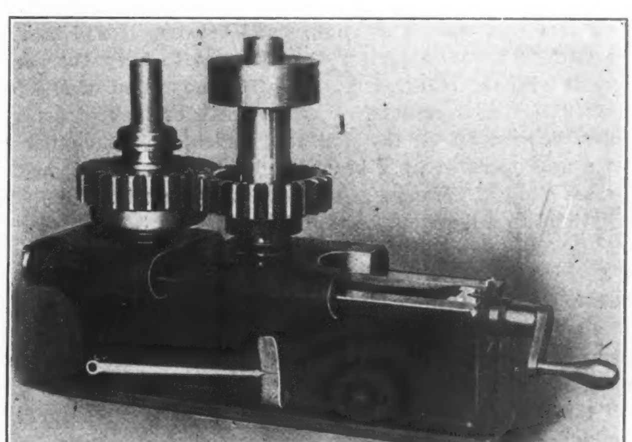


Fig. 10. Fixture for testing Pitch Diameter and Concentricity of Spur Gears

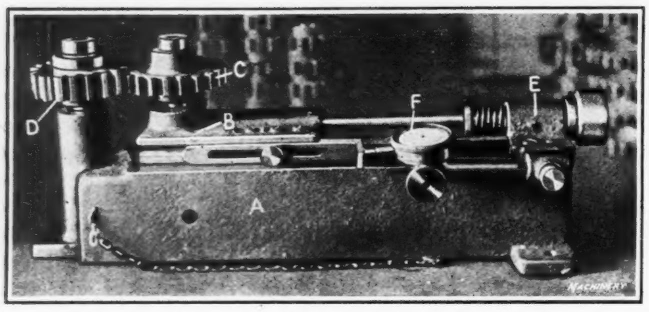


Fig. 11. Fixture for testing Concentricity of Transmission Gears

Fixture for Testing Pitch Diameter and Concentricity of Spur Gears

Another simple but accurate fixture for testing the pitch diameter and concentricity of spur gears is shown in Figs. 10 and 12. The fixture consists of a cast-iron base upon which two accurately fitting slides are held, each slide being provided with a stud for holding the gears being tested. The right-hand slide is moved by means of a long adjusting screw, while the left-hand slide has only a limited movement, but transfers its motion greatly magnified to the indicating needle shown. The sectional view, Fig. 12, shows how the motion is transferred to the indicating needle, which measures the difference in concentricity and errors in mesh to 0.00039 inch.

To detect differences in eccentricity, it is most convenient to place the gear to be tested on the spindle carried in the left-hand slide, and to use a blank with a single tooth on the other. This single tooth is then meshed in succession with all the teeth of the gear under test, and by observing the different positions of the indicating needle, it is possible to determine the eccentricity with great accuracy.

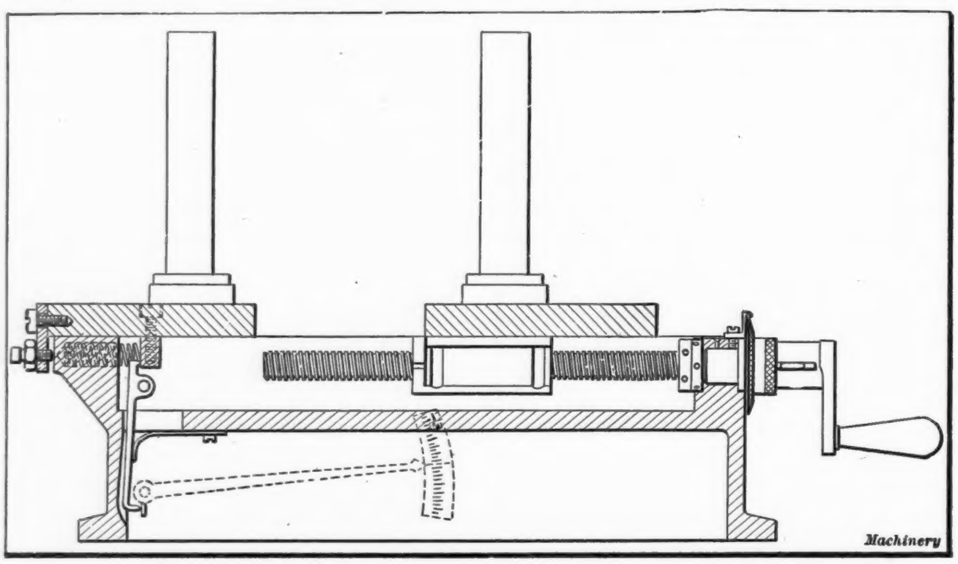


Fig. 12. Sectional View showing Construction of Fixture shown in Fig. 10

Another spur gear testing fixture differing only in a few minor details from that shown in Fig. 9 is illustrated in Fig. 11. This fixture comprises a base *A* carrying a slide *B* on which a stud is mounted for holding the gear *C* to be tested. The master gear *D* is carefully ground all over, and is held on a fixed stud on a projection boss of the fixture. Slide *B* is adjusted by a screw to bring the gears into mesh, the screw being a sliding fit in the boss *E* of the fixture. This screw carries a washer as shown, and between it and boss *E* is a stiff open-wound spring which serves to keep the gears in mesh with the required tension. The movement of slide *B*, which indicates irregularities in the teeth or lack of concentricity, is read off on the dial test indicator *F*, mounted as shown and operated by a bracket adjustably mounted on the movable slide *B*. Transmission gears for automobiles are generally held to a maximum eccentricity of 0.003 inch.

Power-driven Gear Testing Fixture

Another gear testing fixture for automobile transmission and timer gears is shown in Fig. 13. In this case the fixture is power-driven. Briefly, it consists of a cast-iron plate *A* ribbed at the bottom and machined on the top surface; a cast-iron plate *B* with a projecting arm *C* on which is secured a shoulder stud *D;* a cast-iron segment plate *E* drilled and reamed at one end to fit fulcrum stud *D*, and having at the opposite end a shoulder stud *F* on which revolves a master gear of the same pitch as the gear to be tested; an indicator pointer *G* drilled to pass down over fulcrum stud *D* and axle stud *F;* a graduated brass plate *I* secured to the base *A;* and a shaft *J*, the lower end of which revolves on a stud beneath the plate *B*. To this shaft is secured a worm-wheel, and on the part which projects above this worm-wheel the gear to be tested is rigidly secured by means of a key.

The worm *L* is made of machine steel, casehardened, and is driven by a ½-inch half-round belt passing over pulley *M*. A steel spring *N* is fastened to plate *B* and index hand *G*. The segment plate *E* is machined on its bottom face, which slides on the upper face of plate *B*. On the upper face of plate *E* rests the index hand, and on top of this is a steel washer around axle stud *F*. On this washer rests the master gear, which is perfect in every respect. The gear to be tested is revolved by power in the manner indicated, and any irregularity in the diameter is shown on the graduated plate.

Fixture for Testing Concentricity and Thickness of Teeth of Transmission Gears

A gear testing fixture designed especially for handling transmission gears and capable of adjustment so that it can handle various sizes is shown in Fig. 14. The gear to be tested is held on a bushing provided with a squared shank, which is inserted in the holder *A;* this holder is provided with a corresponding square hole and held down in the fixture by means of plate *B*. An ejecting mechanism comprising a handle, as shown, is provided for raising the spindle of the arbor out of the bushing when it is desired to remove the latter. The testing device consists primarily of a slide *C* carrying two teeth of a rack *D*. The latter is held to the slide by means of screws, as shown, so that it can be removed and rack teeth of the desired pitch and shape substituted to suit the work to be handled. The testing is done by means of a Lowe test indicator which is held on bracket *E*. This indicator is constructed somewhat differently from that ordinarily supplied, the shank being cut off short, as shown, and the multiplying lever *F* bearing against pin *G*, which is driven into movable slide *C*. A handwheel *H* attached to a shaft which carries a pinion *I* meshing in a rack in the lower surface of the slide is used for adjusting it back and forth to suit the size of gear being tested. It will be understood, of

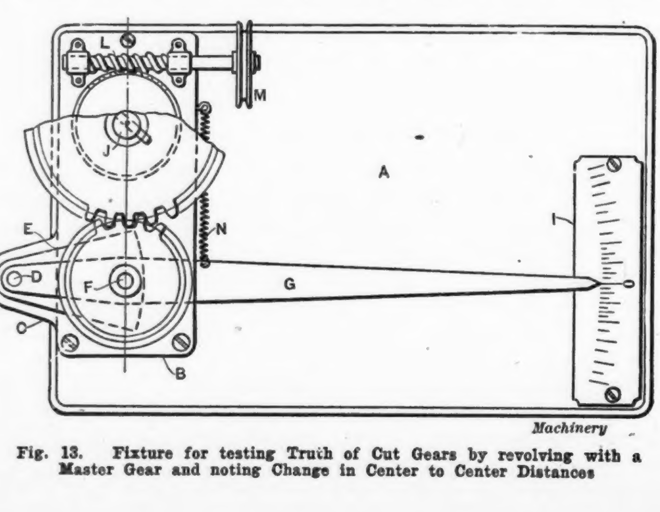


Fig. 13. Fixture for testing Truth of Cut Gears by revolving with a Master Gear and noting Change in Center to Center Distances

course, when testing the gear that after the latter has been placed on the arbor and the arbor inserted in the hole in the bushing *A*, handwheel *H* is operated to bring the rack teeth *D* up in contact with the gear. The gear is then rotated by hand and the movement of the indicator *K* noticed, and if the gear runs out more than ± 0.0015 inch it is rejected. This indicator, of course, is set by means of a master ground gear.

Fixture for Testing Concentricity of Pinion Shafts

An interesting fixture for testing the concentricity of pinion shafts is shown in Fig. 16. This comprises a base *A*, carrying a tailstock and headstock *B* and *C*, respectively; in tailstock *B* is a rigid male center, and in headstock *C* an indicating center. The pinion shaft *E* to be tested is mounted on these two centers. Located in a plane at right angles to the slide of the main body of the fixture is a slide *F*, which carries the master gear *G* and a dial indicator *H*. The teeth in the pinion are kept in mesh with the master gear by means of a spring behind slide *F*. A bracket on the rear side of the fixture carries a second dial indicator *I*, the spindle of which is brought in contact with the ground bearing of the pinion shaft. The third indicator shown projecting from the headstock at *J*, and shown in detail in Fig. 15, is of the multiplying lever indicating type.

As shown in Fig. 15, this indicator comprises a sleeve *A*, which is made a good fit for the hole in the headstock *C*, Fig. 16. It carries a cone-pointed bushing *B*, which projects from the headstock, the pinion shaft being tested having a hole so that the cone bushing supports it on the opposite end from the rigid center. It should be mentioned that the cone-center in the hole has been ground by locating the pinion shaft from the bearing at the rear of the pinion. Sleeve *A*, Fig. 15, is slabbed down on the front end and machined to carry the indicating needle *C*. This, as shown, carries an indicator point *D*, which can be adjusted to suit the diameter of the hole in the work and is locked by the nut shown. The rear end of needle *C* is pointed and moves over an index plate *E*, which is provided with graduations spaced 0.069 inch apart. The multiplying lever has a ratio of 1/8 to 8 5/8 inches, or 69 to 1, so that each graduation on the scale represents 0.001 inch error in the work. The tolerances on this part are: concentricity of pitch circle of teeth, ± 0.0015 inch; tolerance for eccentricity of bearing, ± 0.0005 inch; tolerance for eccentricity of hole, ± 0.0005 inch.

In operation, the pinion *E*, Fig. 16, is located between the centers, screw *K* being adjusted to eliminate end play between

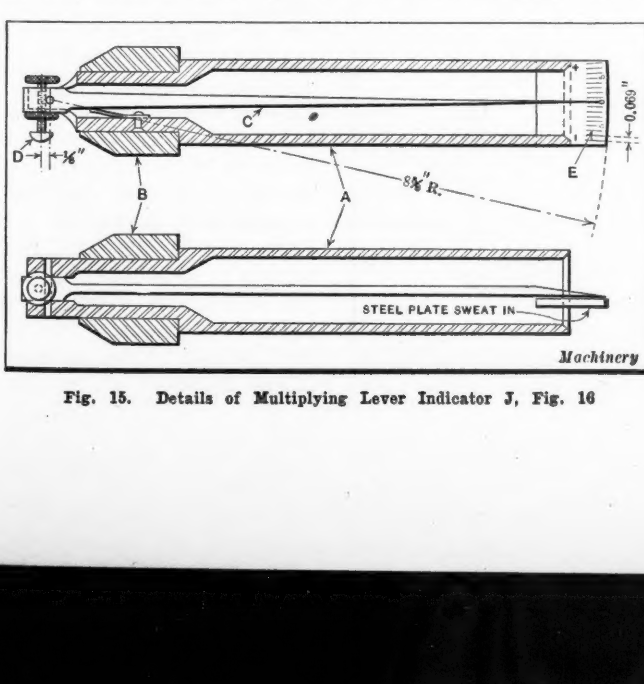


Fig. 15. Details of Multiplying Lever Indicator J, Fig. 16

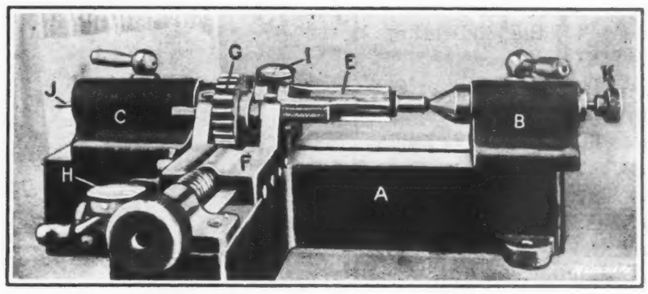


Fig. 16. Fixture for testing Concentricity of Pinion Shaft

the centers. The pinion shaft is then rotated in mesh with the master gear, and the various indicators show the following results: indicator *H* tests the accuracy of the pitch diameter and spacing of the teeth; *I* tests the concentricity of the bearing in relation to the hole; and *J* tests the truth of the hole in relation to the shank bearing diameter. In this way each important part of the pinion shaft can be tested and held to close limits. On gears of this type the maximum eccentricity is 0.003 inch.

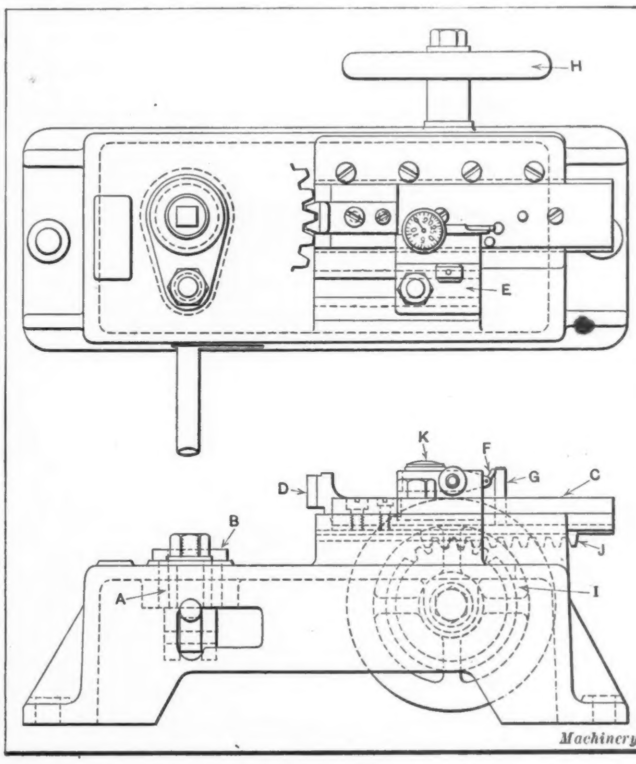


Fig. 14. Fixture for testing Concentricity and Thickness of Teeth of Transmission Gears

Precision Spur Gear Testing Fixture

Fig. 17 shows a precision gear testing device for spur gears. It tests the following elements of the gear: pitch diameter; truth of pitch diameter with hole; thickness of teeth on the pitch line; and parallelism of teeth with axis of gear.

In this fixture revolving stud *A* is mounted in a fixed position and forms a basis from which the principal dimensions are checked. The removable plug *B*, which is mounted on the sliding block *C* that slides in the ways *D*, is located in relation to stud *A* by the locating pin *E*. Blocks *C* and *F* are connected by two bolts, only one being visible in the illustration. One end of the bolts is screwed into block *C*, while the other end is a free fit in block *F*. The blocks are normally separated by two springs on the bolts, the function of which will be explained later.

The indicating mechanism *G* is located in relation to plug *B* by the vernier *H*. The scale of the vernier is fastened to block *C*, while the vernier is fastened to part *I*, making it integral with the indicating mechanism. The vernier and indicating mechanism are adjusted by nuts *K*. The part *J* is secured in the T-slot by the nut directly below it, and is adjustable along the slot, which extends the full length of the fixture. The indicating mechanism and vernier are locked by nuts *L*; the indicating mechanism is adjusted vertically on the pillars *M* and secured by thumb-screws *N*.

In operation, a master gear is placed on driving stud *A*, and the gear to be tested on plug *B*, being free to revolve on the latter. The locating pin *E* is then inserted in the proper hole along the edge of gib *O*, thus locking block *F* securely and locating the two blocks in the proper relation to each other. The gear is now revolved by the master gear, which is rotated by a handle on the squared end of the stud. The indicator then shows if the teeth are concentric with the hole, and if the pitch diameter is correct. While block *F* is locked to gib *O*, block *C* is free to move within certain limits. This movement is indicated on dial *P* by the multiplying levers. If the size of the gear varies or if it is out of round, block *C* will slide back and forth against the tension of the springs,

thus imparting movement to the indicating lever.

The removable gage Q, for measuring the thickness of the teeth, is held against them by spring tension; any variation will then be shown upon the dial by means of the multiplying lever. For testing the parallelism of the teeth and axis, the mechanism is slid up or down along the pillars M. The indicating needles, of course, are set at zero by means of a carefully machined and checked master gear, prior to testing the gears.

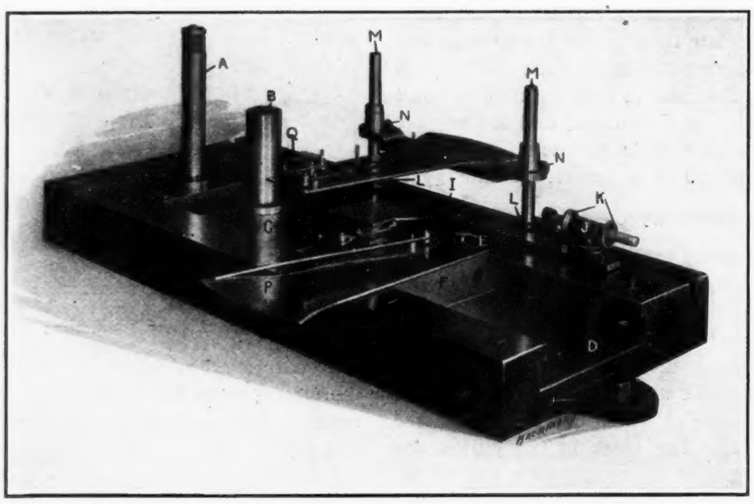


Fig. 17. Device for testing Pitch Diameter, Concentricity of Bearings, Tooth Thickness at Pitch Line and Parallelism of Teeth with Axis of Gear

Fixture for Testing Involute Curve of Spur Gear Teeth

Many interesting devices have been developed for testing spur gears, especially the shape of the involute curve on the teeth. One method consists in rolling the spur gear in contact with a master and determining whether it is correct or not by the feel. Another interesting device, which is shown in Fig. 18, determines the shape of the involute curve in such a manner that the amount of error can be read off on an indicator in thousandths inch. This device, it will be noticed, consists of a base A in which a dovetail slide B is operated by handle C. This slide has a carefully machined slot in its top face, in which a disk D rotates. Disk D is attached to a spindle E, which carries the gear to be inspected, and, in addition, two hardened, ground and lapped disks F and G. These disks run on straightedge H and are made equal in diameter to the base circle from which the involute curve on the gear teeth is laid out.

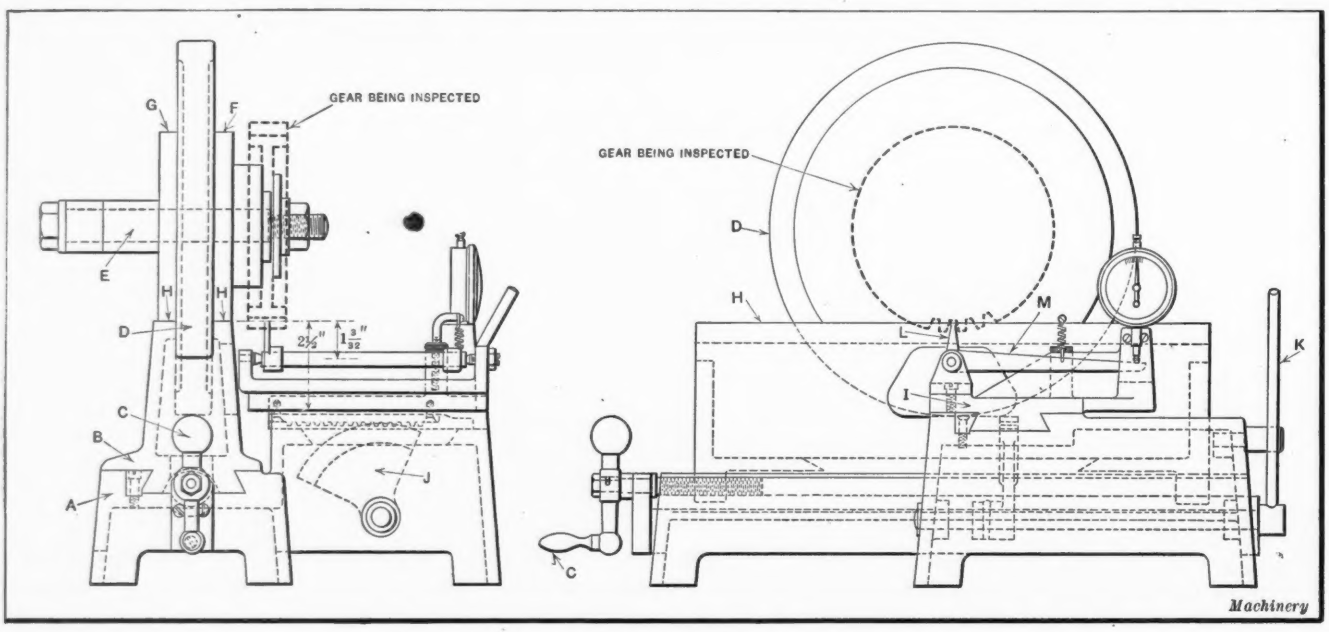


Fig. 18. Fixture for testing Involute Curve of Spur Gear Teeth

Located at right angles to slide B is a secondary slide I that carries the indicating mechanism. This slide, it will be noticed, has a rack attached to its lower surface connecting with the segment gear J that is operated by handle K. For testing the accuracy of the involute curve, the gear, together with the two disks, is rolled along the straightedges and the teeth are brought into contact with the tooth pointer L of the multiplying lever M. This lever transmits a movement to the needle of the indicator. The multiplying lever has a ratio of 10 to 1 and the indicator is graduated in thousandths inch, so that each graduation on the indicator represents 0.0001 inch variation in the shape of the curve. One objection to this device is the shape of the indicator pointer L. Instead of being rounded, this should be made to a sharp point so as to trace the involute curve without introducing any error.

Another use of this testing fixture is to determine whether the teeth of the gear are in line with the axis or not. To make this test the gear and the member to which it is attached are held rigidly on the straightedges. Handle K is operated so that slide I is moved back and forth, passing the indicator point across the face of the tooth, and, of course, in line with the axis. In this way the straightness of the tooth surfaces in relation to the axis of the hole in the gear can be accurately tested.

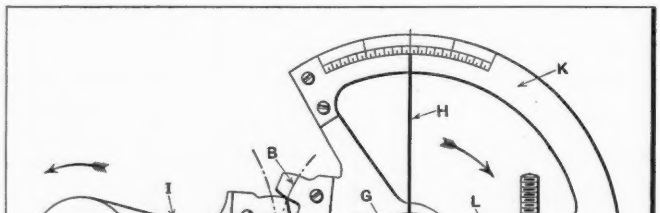


Fig. 19. MacCord Odontoscope for testing Involute Curve of Gear Teeth

MacCord Odontoscope for Testing Gear Teeth Involute Curve

Another system for testing the truth of involute curves is by means of the MacCord odontoscope, shown in the diagram Fig. 19. By this method it is possible to test the accuracy of the involute curve to a nicety. The fixture consists of two templets A and B, which are cut out

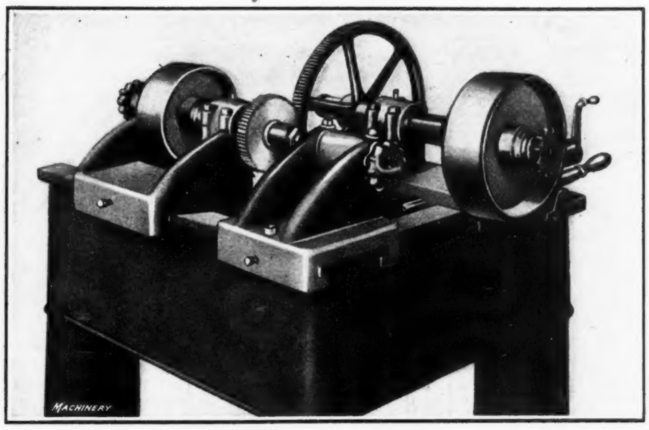


Fig. 20. Fixture for testing Spur Gears for Noise under Load

of fairly thick sheet metal and correspond to the teeth of a pair of gears. These are secured to arms turning about the axes C and D, the distance between which is adjustable. Shaft D carries a graduated segment K, which may be slowly rotated by arm L and tangent screw E or any other equivalent device. Motion is thus communicated to C, the teeth A being kept in contact with B by a light weight or spring, not shown.

Cylindrical barrels F and G are accurately turned to the same diameter as the pitch circle from which the involute curves are struck off. F is fixed on the axis C, while G carries a pointer H that turns freely on axis D and is connected by a spring, not shown. The tendency is to wind the fine flexible wire I up on G, which is secured to both barrels in the manner of a cross belt. It will thus be seen that barrels F and G turn in opposite directions with a constant velocity ratio. The velocity ratio of C and D, however, is determined by the templets A and B that will not remain in mesh unless the contour of the teeth is strictly conjugate. While turning the tangent screw in one direction or the other, it is possible to examine the action during the arc of approach or retreat of the teeth, and if the templets are correctly formed, the segment K and pointer H will move at the same rate and in the same direction, so that if the pointer is set at zero in the graduated arc it will remain at zero throughout the action, any movement indicating an inaccuracy in the shape of the involute curve. For actual work the sensitiveness of the involute is increased by introducing multiplying gears between barrels C and G, thus producing a greater deflection of needle H for a given magnitude, and causing minute errors to be indicated.

Fig. 21. Fixture used in testing Large Bevel Ring Gears for Truth after grinding Back and Front Faces

Testing Spur Gears for Noise under Load

After the gears are cut and inspected for other defects, they are generally given a noise test. In making this test it is the general practice to hold the gears to be tested in some sort of fixture in which a load can be applied while the gears are running at high speed. It is also customary to have the load either approximate or exceed that which will be carried by the gear under actual working conditions. Fig. 20 shows a gear testing fixture for spur gears which embodies the features just mentioned. This consists of a base carrying three slides. The slides at the rear, which are guided by ways on the bed, are held accurately in line with each other and are gibbed to the bed. The right-hand bracket carries a dead center and the left-hand bracket a driving center, rotated by the pulley shown. The gear to be tested is held on a mandrel and is in mesh with another gear held on a spindle that rotates in bronze bearings. The outer end of this spindle carries a disk and band brake.

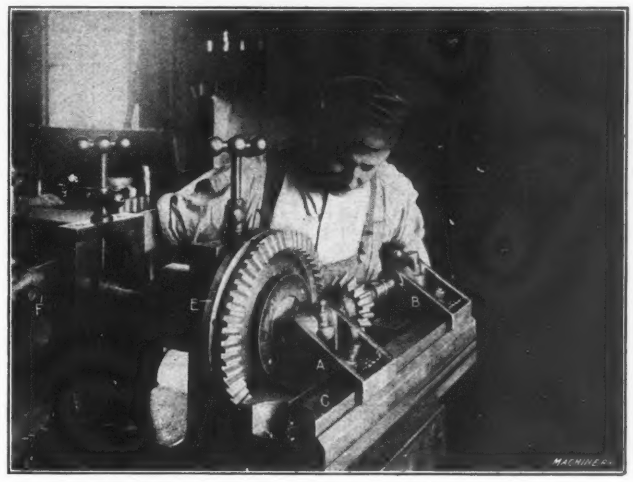


Fig. 22. Running Test for Noise on Bevel Ring Gears and Pinion, accomplished by Hand

In operation, the gear to be tested is located as shown, and the gear on the spindle is brought into mesh with it by the hand-lever at the front of the machine. The power is turned on slowly at first and then gradually increased. At the same time the band is tightened on the disk to increase the power required to rotate the gear on the spindle. The operator meanwhile observes closely the noise produced. If this is in the nature of a singing hum, the gear is all right, but if it is an intermittent noise or clash, it indicates that the teeth are unevenly spaced, eccentric with the hole or incorrectly formed.

Testing Bevel Drive Ring Gears

Several methods are employed for testing bevel drive ring gears for automobile transmissions. One of the most important tests is to determine within fixed limits the relation

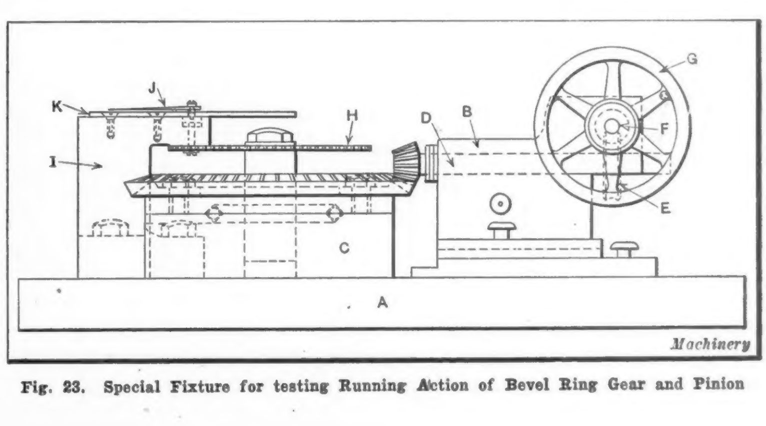


Fig. 23. Special Fixture for testing Running Action of Bevel Ring Gear and Pinion

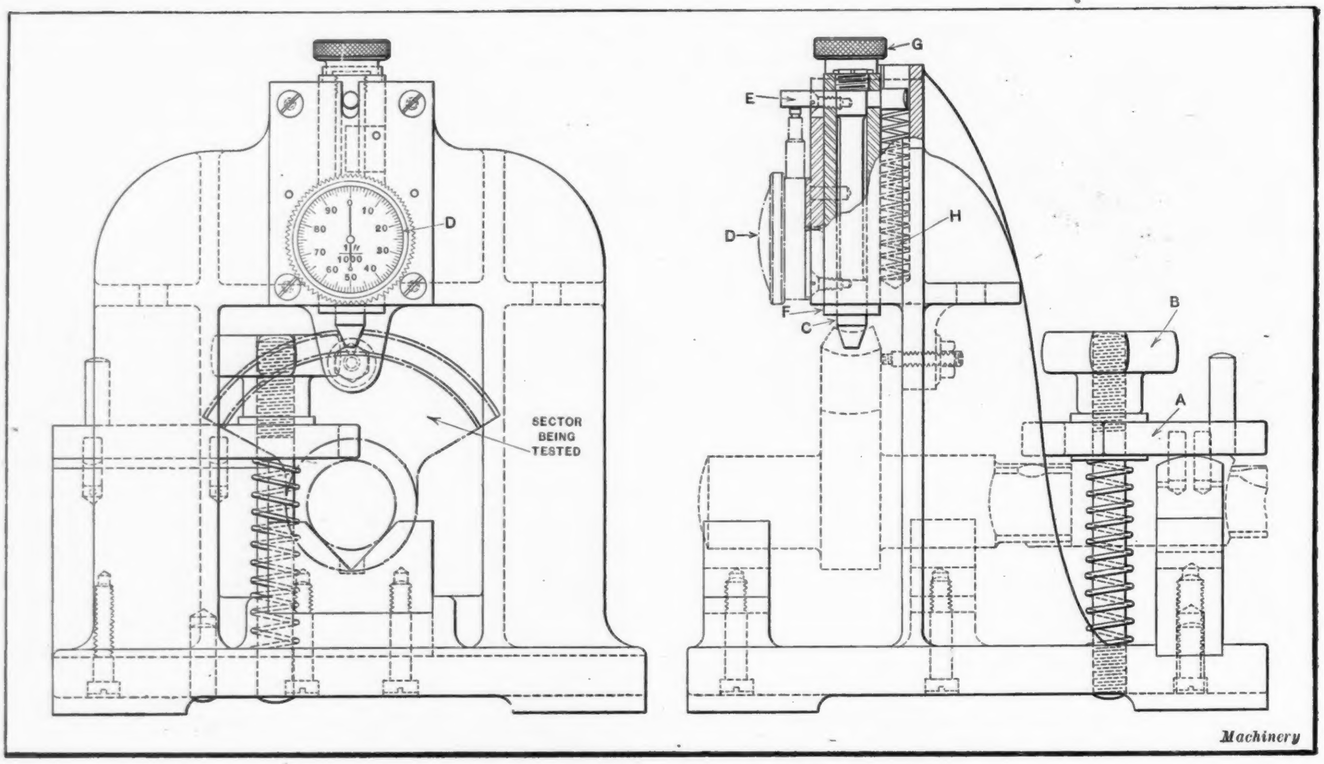


Fig. 24. Fixture for testing Eccentricity of Steering Gear Sector

of the teeth to the back face and hole. In the helical type of ring gear this is generally accomplished by what is known as a ball test. The ring gear to be tested is fastened by the bolt holes to a carefully ground ring, which forms a part of the fixture and is free to rotate. The inspecting is done by means of a dial test indicator held in an arm, in the lower or measuring end of which is a carefully ground and lapped ball that is brought in contact with the teeth being tested. The spindle carrying the ball is kept in contact with the gear teeth by means of a stiff spring, and the ball is raised up out of contact with the teeth by a lever. The spaces between the teeth are tested in this way after the gear has been hardened, and the gear is allowed to run-out about 0.003 inch.

Testing Ground Faces of Bevel Ring Gears

In grinding the rear face of a bevel ring gear, it is the usual practice to locate the gear from the pitch line of the teeth by means of accurate balls. After the front and rear faces and hole have been ground, the gear is tested in the manner shown in Fig. 21. This fixture consists of a cast-iron base *A* to which a hardened and ground steel ring *B* is fastened. In the top face of this ring are carried steel balls on which the gear rests. The ring gear is located from the hole by a hardened and ground stud *C*, which is fastened to the cast-iron base.

The test for truth is accomplished with the test indicator *D* held in the bracket *E*. Bracket *E* is free to swing about the stud on which it is mounted when the clamp shown is released. The inspector, in testing for truth, rotates the gear on the balls as shown in the illustration, and at the same time watches the movement of the indicator needle to see if any inaccuracy has been caused by the grinding operation. As extreme accuracy in this part is necessary, a duplicate fixture is used in the grinding department by the operator (the one who grinds the inside face of the gear) to determine if the final grinding operation is correct before the gears leave the grinding department.

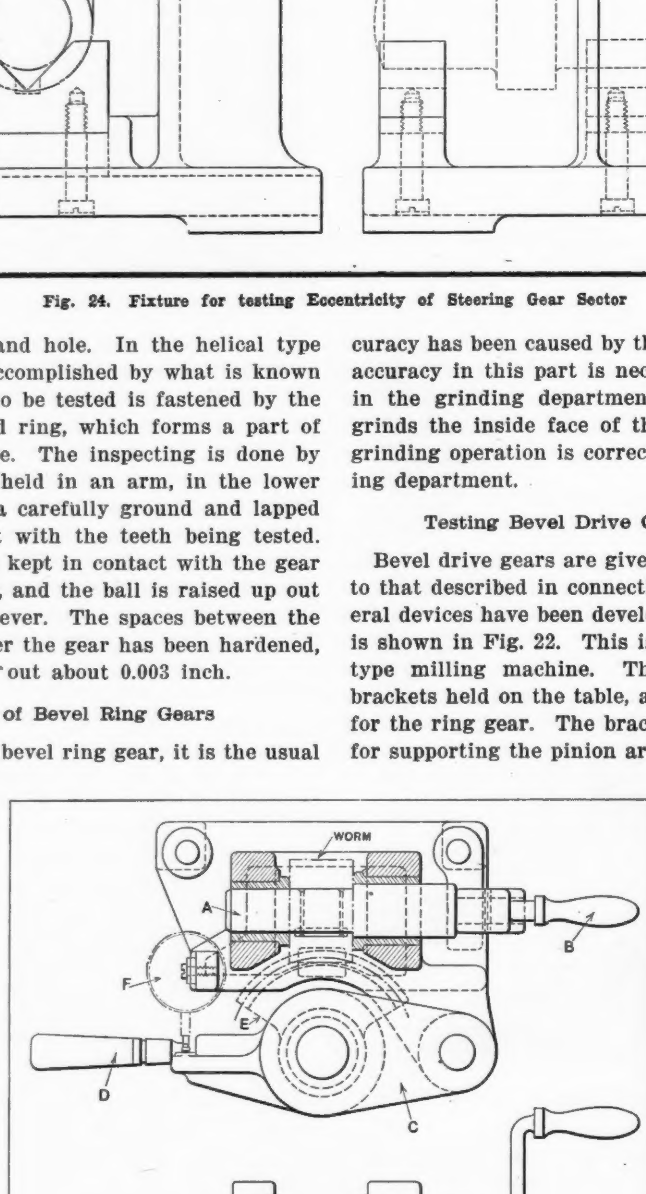


Fig. 25. Fixture for testing Center Distance of Steering Gear Sector and Worm

Testing Bevel Drive Gears for Noise under Load

Bevel drive gears are given a noise test in a similar manner to that described in connection with transmission gears. Several devices have been developed for the purpose, one of which is shown in Fig. 22. This is made out of a discarded Lincoln type milling machine. The testing fixture comprises two brackets held on the table, and a special holder on the spindle for the ring gear. The brackets *A* and *B* which carry centers for supporting the pinion arbor are held to the special table *C* by T-bolts and nuts. The bracket *A* is provided with a wing-nut, so that it can be easily removed to insert and remove the work.

The ring gear is held in a similar manner to that employed in the Gleason bevel gear generator, being located from the front inside face by a shoulder plate *D* to which the gear is bolted. Spring pins located in the special faceplate *E* are also used to support the rim of the gear. The machine is provided with a special hardened and ground spindle on which the ring gear fixture is retained. The spindle is hollow and a pull-rod passing through it is used to clamp the gear and shoulder plate *D* up against the fixture. To the rear end of the spindle is attached the handle *F*, which is used to rotate the ring gear that meshes with the pinion held on the arbor. In use, the operator brings the ring gear

and its mating pinion into mesh, and then rotates the handle *F* slowly, listening carefully to find out at which points of the rotation noise is produced or where the teeth bear hard. In addition to this, the ring gear and mating pinion are given a noise test under load, while being rotated at a high speed.

Testing Running Action of Bevel Drive Gears

A bevel ring gear and pinion must be accurately mounted to give satisfactory results, and in order to determine whether the gear will run correctly or not when mounted, it is advisable in most cases to test the gear under actual working conditions in a special fixture that has been designed for the purpose, and so arranged that any errors in the ring gear are magnified. A simple testing device which gives satisfactory results is shown in Fig. 23, and consists of a base *A* upon which is mounted an adjustable bracket *B* that carries the bevel pinion, and a bracket *C* that carries the ring gear. The pinion shaft *D* is driven by a worm-wheel *E*, which, in turn, receives power from a worm held on shaft *F*, the latter being rotated by handwheel *G*. Mounted upon fixture *C* is the bevel ring gear, which is mounted so that it is free to be rotated by the pinion. Located on the spindle to which the ring gear is attached is a fine-pitch spur gear *H* which meshes with a pinion held in a bracket *I*. The ratio between this spur gear and pinion is 10 to 1. Located on the pinion shaft is a pointer *J* which rotates around the graduated dial *K*, the latter being attached directly to the bracket *I*.

In operation, the pinion and bevel ring gear are carefully mounted and then handwheel *G* is rotated at a uniform speed. If the bevel pinion and ring gear are properly cut and in correct mesh, the indicator *J* will travel over the dial *K* with a steady, uniform motion. On the other hand, if the meshing is incorrect, corresponding with incorrect mounting in use, the pointer will move over the dial with a jerky, irregular motion. The block *B* carrying the horizontal pinion shaft is adjustable so that the gears can be made to mesh incorrectly in order to study the effect of this action. The fixture is so designed, however, that there is one correct position that cannot be varied more than 0.001 inch.

Testing Fixture for Steering Worm Sectors

Fig. 24 shows a testing fixture which is used for determining the amount of eccentricity of a steering worm sector, as used on the Cadillac motor car. This particular steering worm sector is made eccentric so that by adjusting an eccentric bushing any wobble can be taken up in the steering sector until it has been worn down to an "equal radius." The teeth on this sector are not concentric with the shank, and as they wear more in the center than at either end, this allowance for adjustment is necessary. In order to check up the amount of eccentricity on this sector, a special testing fixture has been devised as shown in Fig. 24. Here the steering worm sector is shown, by heavy dotted lines, mounted in two V-blocks and held down just tight enough to prevent any loose motion by means of a toe-clamp *A* and nut *B*. The sector is then swung around past the rack tooth *C*, which, of course, contacts with the teeth in the sector. The amount that the center of the worm is eccentric with the two extreme ends of the sector is then determined accurately by means of the dial test indicator *D*, which is acted upon by the pin *E* held in the slide *F*. This slide is moved up against the tension of spring *H* by pulling on button *G*.

Fixture for Testing Center Distance of Steering Sector and Worm

After the amount of eccentricity of the worm sector has been tested in the fixture shown in Fig. 24, the next step is to test the center distance of the worm in connection with the sector, working the latter on the high point, as indicated in Fig. 25. Here it will be noticed that the worm is held on a shaft *A* provided with a key for driving it, this shaft, in turn, being rotated by handle *B*. The sector is held in a swinging member or arm *C* operated by handle *D*. The worm is placed on shaft *A*, sector *E* is then placed in swinging arm *C*, and the latter is swung in until the sector meshes properly with the worm. From time to time this fixture is tested and set by a master sector and worm and then a reading is taken on the dial test indicator *F*. When the work being tested is put in this fixture, the needle must indicate within ± 0.001 inch of the zero point registered by the master. In order to see that the worm is not eccentric, it is rotated by means of handle *B*, and as the swinging arm *C* is only held in by means of the hand, the eccentric movement of the sector is easily taken care of as the arm is forced back by the rotation of the worm. This, of course, gives an indicating reading on the dial test indicator, and the amount of eccentricity can also be determined in the same fixture.

* * *

SOME CAUSES OF INEFFICIENCY

BY CLARENCE F. GETZLAFF[1]

All machine shops are endeavoring to attain 100 per cent efficiency, but from the writer's point of view—which is that of a machinist—a wrong starting point is usually taken. Most managements seem to think that feeds and speeds are the sole factors of efficiency and production. Although the writer believes that a machine should produce all there is in it, the minute a machine is crowded to its utmost capacity it is being forced beyond the laws of tolerance. Furthermore, burning up tool steel never resulted in efficient production.

More time is wasted on setting up a job than on almost all other operations combined, for the simple reason that a foreman cannot watch a man as closely on the preparatory work as he can on the actual running. But it is not only the machinists that keep down efficiency; the foremen are also at fault. Some of them are so impatient that the minute a casting for which they happened to be waiting comes into the shop, they compel a machinist to break up a job to get out the rush. This means setting up the first job twice, which is likely to cost thousands of dollars a year.

Much time is also lost in the tool-room waiting for tools that are stored on the shelves without a number or other means of identifying them, so that they must be looked for until found. Tools are also often brought back to the tool-room in a broken or burned condition, but are accepted by the tool-room "jack" on account of his lack of knowledge of these things. And, strange to say, drill-press tables are still used as anvils and lathe beds as tool and file racks.

In a good many shops there is a lack of judgment in regard to lubricating and cleaning the machines. In one shop, where the power was supplied by a five-horsepower gasoline engine, the writer called the attention of the owner to the fact that the engine was badly in need of repair. But the owner simply said, "Oh, she is getting weak in the joints, but she is still doing business." How long is a machine allowed to do business after its bearings are worn, and how does it run after it comes out of the repair shop?

* * *

WIDE-FACE GRINDING WHEELS

A comparatively short time ago a grinding wheel with a 1½-inch or 2-inch face was considered a wide-faced wheel, but the demand for greater production and lower manufacturing costs has brought wider and wider wheels into use, and now wheels ranging from 3 to 12 inches face are common. Their introduction has brought about a change in machine design and construction; more power and greater weight and rigidity are essential. The spindles must be of the best material, with ample bearing surfaces and large, well made boxes. Greater economy in the production of special shapes (form grinding) has resulted from the wide wheel practice. Production has been increased and the field of cylindrical grinding has been widened. Work up to 10 inches long is now ground with a wheel of 10-inch face without traversing. The non-traversing method is correct for all work that does not have an exceedingly close limit, or which is not so delicate and frail that it is not practicable to take the extra heavy cut. Longer work than 10 inches is traversed with advantage, but even then production is increased by the use of wide wheels, provided the traverse of the work is practically equal to the width of the wheel for each revolution of the work.—*Howard W. Dunbar in "Grits and Grinds."*

[1]Address: 944 Eleventh St., Milwaukee, Wis.

MOLYBDENUM AND ITS USE IN STEEL[1]

Molybdenum is said to impart remarkable drawing qualities to nickel steel, and to make armor plate, when annealed, more readily planed, at the same time increasing the strength of the hardened steel. Its effect on steel is similar to that of tungsten, but it is much more active. While molybdenum is as abundant as tungsten and costs only one-third as much, its use in steel manufacture has been greatly retarded by the poor results obtained by the first experimenters; but these results were due to impurities in the molybdenum and to the heat-treatment given to the steels.

Pure molybdenum is a malleable white metal that will not scratch glass and is sufficiently soft to be filed and polished. Its exact melting point is not known. The Bureau of Standards has placed it at about 2500 degrees C. Osmium, tantalum, and tungsten are the only metals with higher melting points. Its specific gravity increases appreciably with the amount of mechanical working to which it is subjected. The General Electric Co. has found that the specific gravity of ductile molybdenum before drawing is 10.02; and after drawing, 10.04 for a wire 3.75 millimeters in diameter, and 10.36 for a wire 0.038 millimeter in diameter. The tensile strength of molybdenum wire 0.0028 inch in diameter is from 230,000 to 270,000 pounds per square inch; of tungsten wire of the same size, 480,000 to 530,000 pounds; and of hard-drawn piano wire 0.003 inch in diameter, 507,000 pounds.

Molybdenum produced by the reduction of molybdic oxide with carbon in an electric furnace does not possess the same physical properties as pure molybdenum, owing to its absorption of carbon. It is gray, brittle, very hard, scratches steel and quartz, and has a much lower melting point and specific gravity than the pure metal. When pure molybdenum is surrounded with carbon and heated to about 1500 degrees C., it absorbs carbon and becomes hard; when carbon-bearing molybdenum is melted with molybdenum dioxide, the product takes on the physical properties of the pure metal.

Molybdenum increases the tendency of steel to harden on cold-working and the effects of oil quenching followed by tempering, but the effect produced depends to a large degree on the treatment of the steel. Molybdenum considerably increases the tensile strength of normalized steel with only a slight reduction of ductility; this influence is most marked in high-carbon steel. Hardened and tempered steel containing 1 to 2 per cent of molybdenum shows very high tenacity values accompanied by high ductility, but higher percentages of molybdenum, when hardened and tempered, make the steel inferior.

Molybdenum steel is generally made by the crucible process though the electric furnace and the open-hearth processes are used. The molybdenum is added in the form of molybdenum powder or ferro-molybdenum. The latter contains about 80 per cent of molybdenum and has a melting point several hundred degrees C. lower than that of the ordinary commercial brands of powdered molybdenum. Besides, the powdered metal seems to be more prone to oxidation than the ferro-alloy, but it generally contains 4 or 5 per cent of various oxides of molybdenum that may aid in removing excess carbon. Molybdenum is also added in the form of alloys of chromium, tungsten, nickel, vanadium, etc. Standard alloys of this type are chrome-molybdenum, which contains 50 per cent of each element; molybdenum-nickel, which contains 75 per cent molybdenum and 25 per cent nickel; and ferro-molybdenum-tungsten, which contains molybdenum and tungsten in the proportion of 3 to 1. From 1 to 7 per cent vanadium is sometimes added to the last-named alloy.

In the presence of chromium and manganese, molybdenum acts similarly to tungsten and in combination with either of these elements and carbon it produces a self-hardening steel that is said to be a little tougher than the corresponding tungsten steel. A typical steel of this kind contains 4 to 6 per cent molybdenum, 1 to 2 per cent chromium, and 1.85 per cent carbon. The addition of molybdenum also enables a steel to retain its temper and hardness at a red heat. These qualities are developed by cooling the steel moderately fast from a high temperature—treatment that prevents the usual critical changes and keeps the steel in the austenitic condition. Many think that high-speed steels produced with molybdenum are superior to the corresponding tungsten steels both as regards toughness and durability; they also take a fine cutting edge. The superior toughness of these steels is attributed to the fact that they contain more iron, as less molybdenum than tungsten is used to obtain the same result. Besides, a lower heat is required in their tempering. If a temperature of 1000 or 1100 degrees C. is exceeded, the life of the tools may be shortened.

Some users claim, however, that molybdenum tool steels are likely to crack in quenching and that they do not hold their cutting edge after retreatment as well as before. This deterioration in the steel upon repeated heating for dressing and treatment has been ascribed to the disappearance of molybdenum from the outer skin of the steel through volatilization. Others have found that this steel is likely to be seamy and to contain physical imperfections; also, that it is likely to fire-crack under treatment. In a few instances, service tests with these steels have shown irregular cutting speeds and have indicated the tendency of the molybdenum to render the tools brittle and weak in their bodies.

Molybdenum tool steels of high carbon content require great skill in their preparation, owing to the difficulty of judging by color the definite temperature required for hardening. Further, great care is necessary in annealing, after it has been worked into bars and before it is cut into shapes for tools, previous to hardening. Most of these objectionable features are probably due to the use of impure ingredients in the manufacture of steels or to improper heat-treatment. Most American manufacturers use molybdenum in conjunction with tungsten, cobalt, chromium, manganese, nickel, and vanadium, for many of the difficulties are thus avoided. Characteristic steel of this type contains 16 to 18 per cent tungsten, 1.5 to 2 per cent molybdenum, 4 to 4.5 per cent chromium, and 0.6 per cent carbon. This steel is said to be superior in cutting efficiency to the corresponding tungsten-chromium steel and to have a finer texture. A high-speed steel in which cobalt is used in conjunction with tungsten, contains 16 to 18 per cent tungsten, 4 to 5.5 per cent cobalt, and 0.25 to 1.5 per cent molybdenum. The addition of small percentages of vanadium is said to increase the strength and cutting efficiency.

The molybdenum steels used in making permanent magnets are similar in composition to the high-speed molybdenum steels. They generally contain from 2 to 3 per cent molybdenum, 0.5 to 0.7 per cent carbon, and sometimes about 0.5 per cent chromium. Some of these steels, however, contain as much as 6 per cent molybdenum. After hardening, these steels retain their magnetism longer than hardened carbon steel and are said to be superior to tungsten magnet steels. An alloy containing 2 to 5 per cent molybdenum, about 10 per cent chromium, and little or no carbon is said to be practically acid-proof. Molybdenum-tungsten-chromium-iron alloys have also been made that are insoluble in hydrochloric, sulphuric, or nitric acid, and an alloy containing 60 per cent chromium, 35 per cent iron, and 2 or 3 per cent molybdenum is said to resist even the action of boiling aqua regia. Differences in the heat-treatment of these alloys have a great effect on their acid-resisting qualities. The addition of molybdenum gives a wider heat-treatment range and greater tensile strength to chrome-nickel steel. The high tensile strength and elastic limit of steel containing 1 per cent chromium, 2 to 3 per cent nickel, and 0.25 to 0.5 per cent molybdenum make them of special value for crankshafts, propeller shafts, and other machine parts that are subjected to alternating and repeated stresses. These steels are also employed in the manufacture of guns of large bore and rifle barrels as they are highly resistant to the erosive action of the gases generated by the explosives.

Small percentages of molybdenum are used in certain patented non-ferrous alloys consisting essentially of chromium and cobalt. These alloys are known under the trade name of stellite and possess remarkable high-speed qualities when used for machine tools. They are also employed for cold chisels, woodworking tools, cutlery, etc. Their use in cutlery is of particular interest, as they do not tarnish under atmospheric influences and are unaffected by fruit acids.

[1] Extract from the bulletin, "Molybdenum; its Ores and their Concentration," issued by the United States Bureau of Mines.

Manufacture of Steel Balls-2

by

Edward K. Hammond[1]

A visitor who is conducted through the plant of the Hoover Steel Ball Co. of Ann Arbor, Mich., finds it exceptionally easy to become acquainted with what is going on in each shop, because, although the plant is large, it is engaged in making a single product, manufacturing operations on different sizes of balls being conducted in essentially the same way throughout. This condition stands out in marked contrast to that found in plants engaged in the production of a variety of different parts, as the manufacturing operations necessarily vary, making it more difficult to see just what is being done.

Fig. 18 shows the condition of the product at each step in the process of manufacture, and it will be of interest to study this illustration carefully, as it shows just what is done to the balls by each operation through which they pass before completion. At *A* is shown a string of hot-forged ball blanks before they have been sheared apart, and at *B* are illustrated two ball blanks made by the cold-heading process. Blanks produced by either of these methods are first subjected to a rough dry-grinding operation which reduces them to an approximately spherical form, as shown at *C*, although the surface is covered with a multitude of small flats and scratches left by the grinding wheel. At *D* are shown two rough-ground blanks after they have been subjected to the process of heat-treatment, and it will be noticed that their appearance is essentially the same as that of the rough-ground blanks shown at *C* except that the surface is darkened as a result of the heat-treatment. Two blanks are shown at *E*, which have received the finish dry-grinding after being hardened, and it will be noticed that the appearance of these blanks is the same as that of the rough-ground blanks *C* except that the flats and scratches are not so pronounced. At *F* and *G* are shown two blanks that have gone through a process known as "oil-rolling" and two blanks that have been through the oil-grinding process. The appearance of both these balls is practically the same except that the oil-ground balls have been reduced to exactly the desired size. At *H* are shown two finished balls after being polished, ready to be sent on to the inspection department, where they will be subjected to a series of rigid tests.

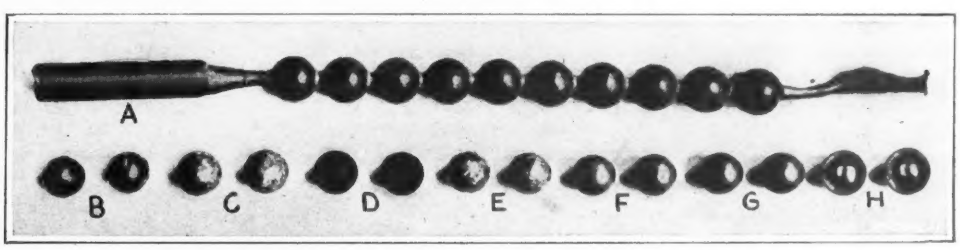


Fig. 18. (A) String of Hot-forged Ball Blanks. (B) Ball Blanks made by Cold-heading Process. (C) Rough Dry-ground Balls. (D) Rough Dry-ground Balls after hardening. (E) Finish Dry-ground Balls. (F) Oil-rolled Balls. (G) Oil-ground Balls. (H) Polished Balls ready for Inspection

Oil-rolling Balls in Tumbling Barrels

After receiving the finish dry-grinding, the balls are of approximately spherical form, but the surface is covered with flat spots and scratches left by the grinding wheel and there is still a considerable amount of excess metal on the balls to be removed. The first step is to subject them to a process known as oil-rolling, which consists of tumbling a charge of balls in an iron barrel containing oil and abrasive. This oil and abrasive is refuse from machines on which a subsequent operation known as "oil-grinding" is performed; this operation will be described in detail later, and the nature of the abrasive will be explained at that time. Most of the tumbling barrels used in this department have capacity for a charge of 1500 pounds of balls, and these were built especially for the Hoover Steel Ball Co.; but some 800-pound barrels made by the Baird Machine Co. of Bridgeport, Conn., are also employed. Some of these barrels are shown in operation in Fig. 19. The purpose of oil-rolling is to smooth off the flats and scratches left by the dry-grinders and to remove excess stock, about 0.004 inch being allowed for removal in the oil-grinding operation. Balls up to 1½ inch in diameter are given this oil-rolling treatment.

It is necessary to leave the balls in these tumbling barrels from twenty to thirty-six hours, according to the amount of stock that must be removed, and as each ball rotates in such a way that its entire surface is uniformly exposed to the action of the abrasive and of the balls adjacent to it, this treatment results in the production of perfect spheres. Experience enables the foreman of the oil-rolling department to judge with considerable accuracy the length of time that it is necessary to leave balls in the tumbling barrels in order to reduce them to the proper size for oil-grinding. When this time has almost expired, a number of balls, selected at random from the contents of each barrel, are taken out and measured with a micrometer in order to see how closely they approach the required size. The oil-rolling is then continued with successive gagings until the balls have been reduced to the required dimension plus 0.004 inch, after which they are removed from the barrels, cleaned, and then taken to the oil-grinding department. In reducing balls by the process of oil-rolling, it occasionally becomes necessary to add more abrasive to the supply of oil and abrasive obtained from the oil-grinders. When this is done, No. 36 carborundum is used, as this coarse-grain abrasive increases the speed at which the balls are reduced to the required size.

How the Process of Oil-grinding is Conducted

There are two grades of balls made in the Hoover factory, known as "Micro-chrome" and "A grade" balls, the former

[1] Associate Editor of MACHINERY.

being the better quality. Both grades are reduced to the final size by the process known as "oil-grinding" that is conducted on machines of the form shown in Figs. 20 and 22. The construction and operation of the oil-grinding machines will be best understood from Fig. 22, which shows details of its construction. These machines are provided with two iron rings *A* and *B*, each of which has an annular groove cut in it of a suitable size to accommodate the balls *C* to be ground. It will be noted that there is a small groove at the bottom of the annular groove in the lower ring *A*, which provides for holding a supply of oil and abrasive. Ring *A* has the annular groove for the balls cut at the bottom of a larger groove, and ring *B* has a flange in which the ball groove is cut that drops into this large groove in ring *A;* the arrangement will be readily understood from the illustration. It will, of course, be understood that the grinding ring is filled with balls, the number that constitutes a complete charge varying according to the size of balls that are being ground.

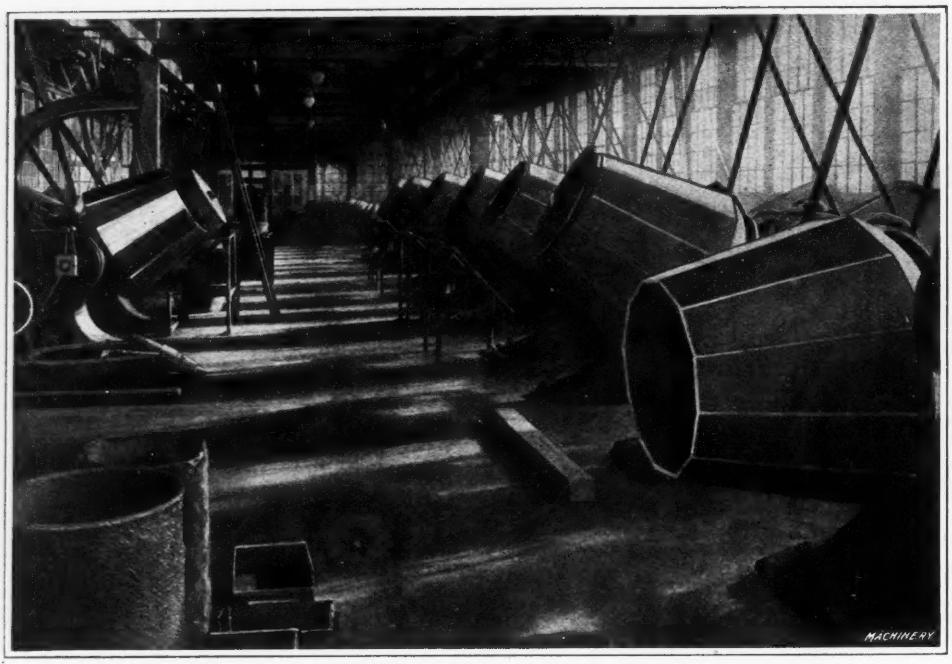


Fig. 19. View in Oil-rolling Department, showing Special Tumbling Barrels of Large Capacity

To provide for loading and unloading the machine, lower ring *A* is drawn out onto a table *D* which is provided for that purpose, and after a fresh charge of balls has been put in place, this ring is pushed back into position under the upper ring *B* that is secured to the spindle of the machine. A sheet metal shield is then pushed into place in front of the rings in order to prevent splashing of the oil. Ring *A* is located in approximately the desired position by means of a hole in the machine bed into which an extension on the under side of ring *A* drops, but the extension on this ring is a loose fit in the hole to allow ring *A* to align itself properly with ring *B*.

The upper ring is secured to the spindle, and in order to start the grinding operation it must be lowered into contact with the balls carried in the annular groove of ring *A*. This is accomplished by a rack on the spindle sleeve that meshes with pinion *E* secured to lever *F*.

In order to raise ring *B* out of contact with the work so that ring *A* may be drawn out onto turntable *D*, lever *F* is pulled down into the horizontal position shown in the illustration. In this position spring latch *G* drops into a notch on ring *H* that is secured to the frame of the machine, thus holding ring *B* in the suspended position. After the machine has been reloaded and it is desired to drop ring *B* into contact with the work preparatory to starting the grinding operation, spring latch *G* is withdrawn from the notch in ring *H* by pulling back grip *I* that is connected to the end of the rod on which latch *G* is carried. Then the wheel is lowered by gravity, care being taken to hold tight to the crank at the end of lever *F* so that it is slowly raised to a vertical position instead of flying up and allowing ring *B* to drop heavily onto the balls carried in the lower ring.

It will be seen that there are three grinding heads provided on each machine, and these are furnished with independent tight and loose pulley drives, so that any head may be stopped without interfering with the operation of the other two. This is done by throwing the belt from the tight to the loose pulley by means of lever *J*, which actuates the belt shifter. The oil-grinders are provided with a dial similar to that of a clock, so that the time for grinding can be observed; the grinding operation usually takes from twenty to forty-five minutes, according to the size of the balls and the amount of stock that must be removed. When the machine is set up ready to start the grinding operation, this dial is set to the approximate time at which the grinding operation will be completed, and a little while before this time is reached several balls are selected at random from different points around the ring, and are measured with an indicator to see how near they come to the required size. The dials on the machine and the test indicator are shown in Fig. 20.

Cleaning and Polishing Oil-ground Balls

As soon as the balls have been ground down to the desired diameter, they are removed from the machine and taken to tumbling barrels containing hardwood sawdust, in which they are rolled for a sufficient length of time to clean off all oil and abrasive. The charge in each tumbling barrel is then taken out and put into riddles through which the sawdust is sifted, as shown in Fig. 21, to separate it from the balls; the balls next go to the tumbling barrels containing a mixture of oil and Vienna lime. They are rolled in this mixture for a sufficient length of time to give them a preliminary polish, after which they are removed and again cleaned in tumbling barrels filled with hardwood sawdust. The sawdust is sifted from the balls in riddles, after which they are rolled for from twenty to twenty-five minutes in kegs containing strips of kid similar to that from which gloves are made, the arrangement of this polishing equipment be-

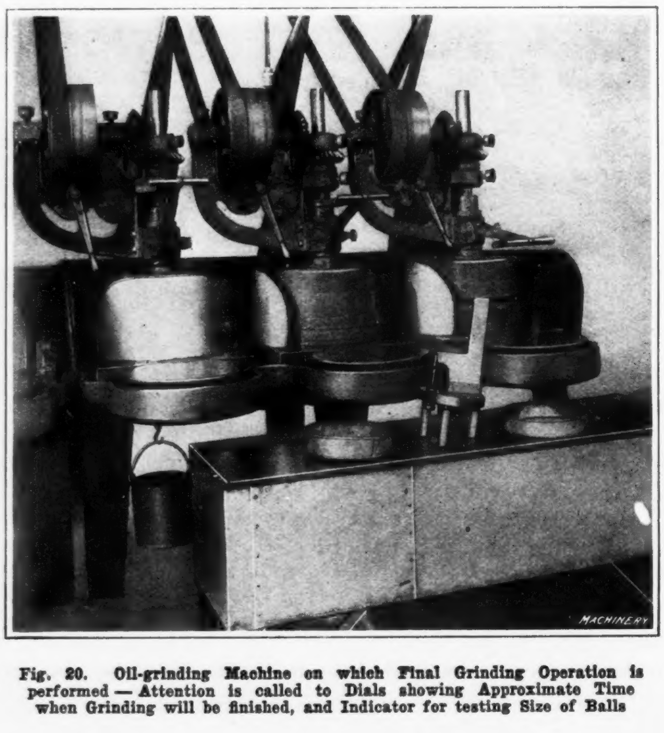


Fig. 20. Oil-grinding Machine on which Final Grinding Operation is performed — Attention is called to Dials showing Approximate Time when Grinding will be finished, and Indicator for testing Size of Balls

ing shown in Fig. 23. Rolling the balls in this way gives them a high polish, which is the final step in the process; and the finished balls are then ready to be taken to the inspection department.

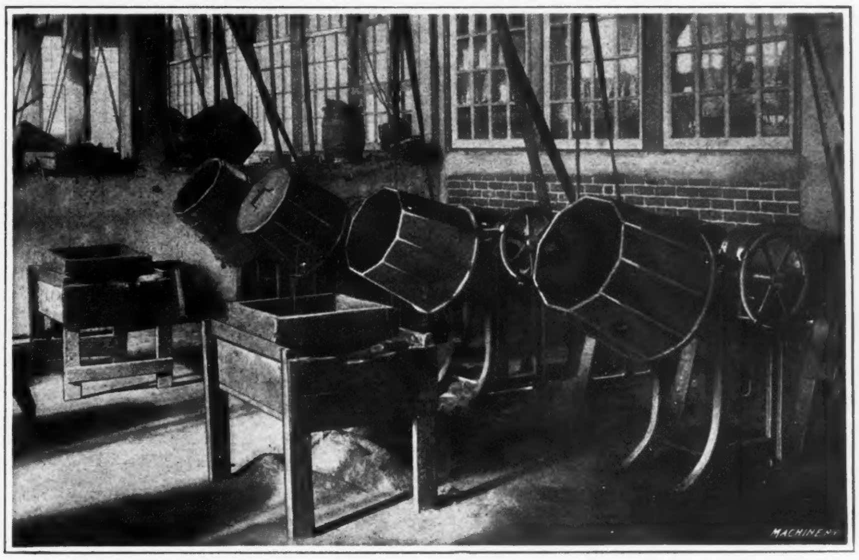


Fig. 21. Small Tumbling Barrels for cleaning Balls in Sawdust, and Riddles for separating Sawdust from Balls

The following data concerning conditions under which oil-grinders are operated and abrasives and oils used on these machines will prove of interest. It has been mentioned that two grades of balls are made, which are known as "Micro-chrome" and "A grade," the former being the better quality. On the "Micro-chrome" balls the grinders are run at 195 revolutions per minute and the abrasive used is a mixture of No. 3-F carborundum and "Atlantic Red" machine oil made by the Standard Oil Co. On "A grade" balls, the grinders are run at a speed of 325 revolutions per minute and the abrasive is an equal mixture of Nos. 180 and 150 carborundum to which No. 4 "Road Oil" is added, this oil also being the product of the Standard Oil Co. Used oil and abrasive from the grinding machines is collected and used in the tumbling barrels.

Special Treatment for Large Balls

Certain variations from the practice described in the preceding paragraphs are necessary in the case of large sized balls which would be too heavy to handle in tumbling barrels. For instance, "A grade" balls over 1½ inch in diameter and "Micro-chrome" balls over ⅝ inch in diameter are burnished on oil-grinders running at high speed and in which very fine abrasive and light oil are used instead of being subjected to a tumbling operation in barrels containing a mixture of oil and lime, as previously described. If large balls of this kind were put in a tumbling barrel, there would be too much shock from the balls striking one another; hence the variation in practice.

Production of Oil-rolled Balls

It has been explained that in the regular process of manufacture the balls go from the tumbling barrels to the oil-grinders on which they are reduced to the required size ready for polishing. There are some poorer grades of balls, however, that do not go to the oil-grinders; these balls are reduced to size by oil-rolling in the tumbling barrels, after which they are polished and sent to the inspection department. The method of polishing is the same as that to which the better grades are subjected, which was previously described. In oil-rolling the balls, a mixture of No. 36 carborundum and No. 4 "Road Oil" is used in the tumbling barrels.

Manufacture of Brass and Copper Balls

In addition to its regular product, the Hoover Steel Ball Co. does quite an extensive business in the manufacture of brass and copper balls of various sizes. One important use of these balls is for various forms of valves, although they find a number of other applications. The general features of the methods used in producing these balls are the same as those employed in making steel balls, but there are certain modifications which will prove of interest. Brass and copper ball blanks up to 1¼ inch in diameter are produced on Manville cold-headers, and blanks for balls exceeding this size are cast. In the case of very large balls the practice is often adopted of making the blanks hollow, which is done by casting them

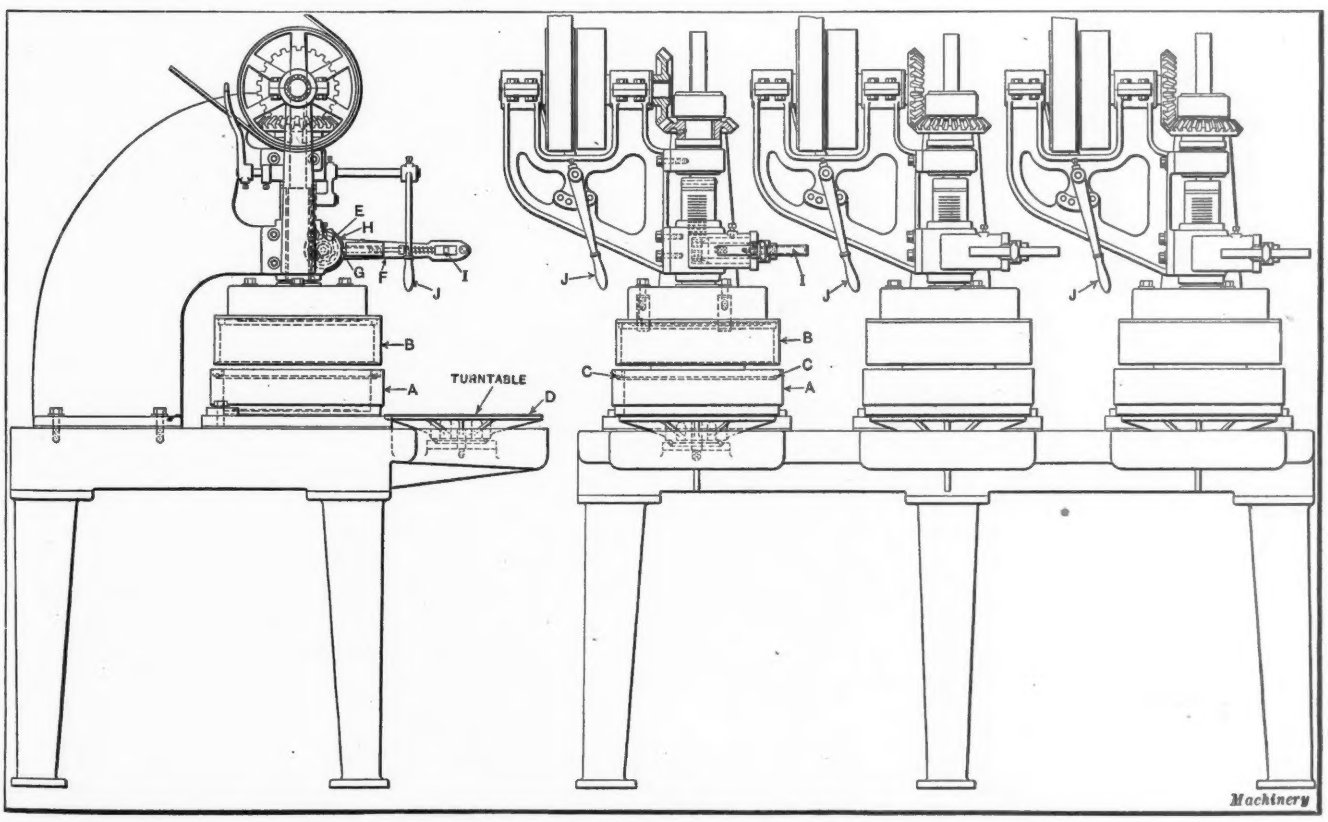


Fig. 22. Side and Front Views of Oil-grinding Machine, illustrating Method of Operation

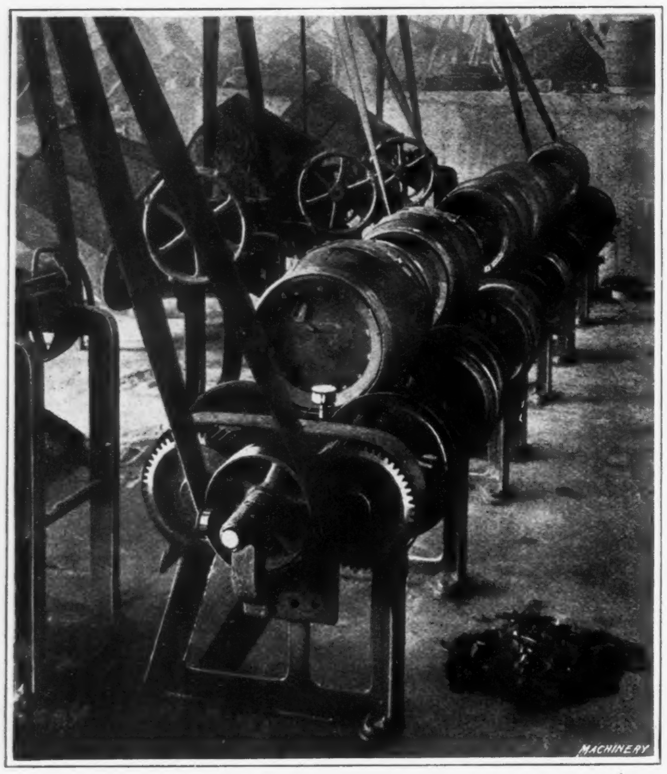


Fig. 23. Kegs in which Balls are polished by rolling in Leather — Attention is called to Small Pile of Leather on Floor in Foreground

with a sand core that is subsequently removed. Then in order to prepare the blank for finishing, the holes left by the core prints are drilled, reamed and tapped so that threaded plugs may be screwed in. These hollow ball blanks are then subjected to the regular process of manufacture, and it is a difficult matter to detect the place where the plugs have been screwed in.

As in the case of steel balls, these blanks are first subjected to a process of dry-grinding to make them approximately spherical. Brass and copper balls are too soft to stand treatment in tumbling barrels, as they would be covered with bruises from impact with each other. After being dry-ground, they receive the regular process of oil-grinding and are then polished in machines of the same design as those used for oil-grinding; but in polishing, the balls are rolled in oil without any abrasive, which results in giving them quite a high polish, although the surface produced is not as highly finished as in the case of steel balls which are subjected to burnishing and polishing operations after being oil-ground. In treating brass and copper balls in the oil-grinding machine, care must be taken not to subject them to too great pressure, and in order to guard against this the rings on the machine are filled with brass and steel balls arranged alternately; the steel balls support the pressure of the upper ring and the head on which it is carried, and allow the balls to be ground and polished without being subjected to sufficient pressure to flatten them.

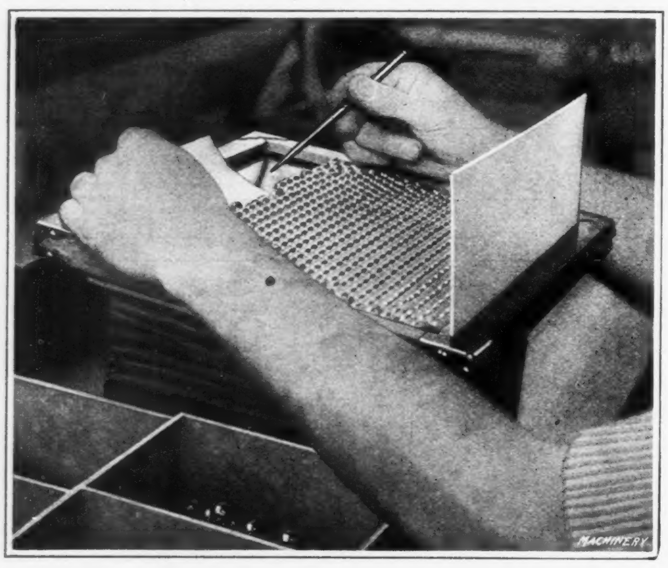


Fig. 24. Type of Glass Plate on which Preliminary Inspection is conducted

Inspection of Finished Balls

After each step in the process of manufacture, the balls receive a general inspection to make sure that nothing is wrong with the adjustment of the machines or with the material from which the balls are made that will prevent the production of balls that come up to the standard. After receiving their final polish, the finished balls go to the inspection department, where they are subjected to a number of searching tests in order that all defective balls may be eliminated and that those balls which pass inspection may be divided into various grades according to the accuracy of their dimensions.

The first step is to clean the balls thoroughly, which is done by placing them in metal baskets provided with long handles so that the load of balls may be dipped into gasoline to remove grease and particles of leather carried over from the polishing department. After this washing, the balls are put into canvas bags and rolled on a table so that the bags will absorb the gasoline and wipe off the dirt. The balls are given a preliminary wiping in one of these bags, after which they are placed in a second bag that is cleaner and insures the removal of the last traces of gasoline and dirt.

Fig. 25. Close View of Battery of Automatic Gaging Machines with Inclined Blades

Making Plate Inspection

After cleaning, the first actual examination is conducted on what are known as "inspection plates," one of which is shown in Fig. 24. These plates are used on benches that run all the way around the two inspection rooms, so that advantage may be taken of the liberal amount of daylight provided by the windows which extend from below the bench up to the ceiling. The plates are made of glass and painted black. A reflector is set up at the back of each inspection plate which throws light on the balls; and a strip of thin flexible cardboard is drawn back and forth beneath the balls to rotate them and bring all surfaces into view. Several times while making this inspection, all the balls on the plate are rubbed with a cloth

to change their axes of rotation and insure exposing the whole surface. The first step is to pick out balls having fire cracks, flats, etc., and these are sold to novelty manufacturers for use in the familiar form of toys that return to a standing position after being tipped over, due to a ball which rolls down to the lowest point at the cavity in the center.

During the next step in the process of inspection, attention is paid to a white spot on each ball that is thrown from the reflector at the back of the inspection plate. As previously mentioned, a card is drawn back and forth under the plates to make them revolve, and the inspectors first pick out what are known as "wigglers," which is the name given to balls that are out of round and go through a series of contortions while being rolled. After this has been done, the balls on the plate are gone over carefully and all those that show any defect are picked out. During this process of inspection, the balls are sorted into eight grades, as follows: (1) "Fire cracked," balls that have been cracked during the process of heat-treatment; (2) "Junk", balls which have flats, holes, etc.;

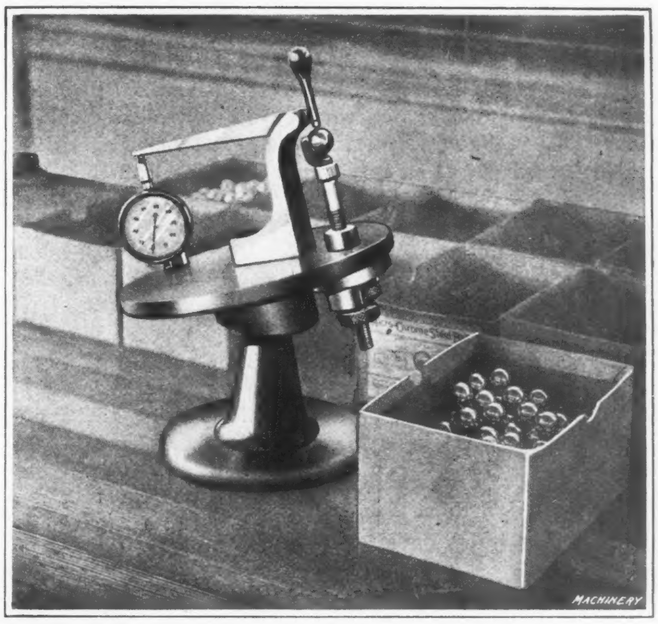


Fig. 27. Dial Indicator with 10 to 1 Leverage Ratio, for testing Accuracy of Balls to 0.0001 Inch

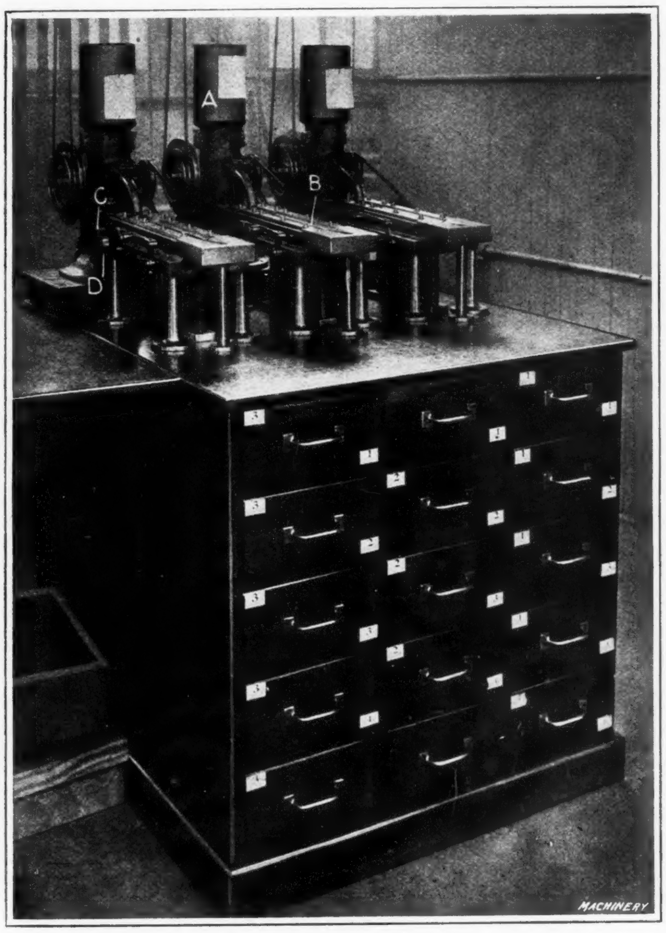


Fig. 26. Close View of Battery of Automatic Gaging Machines with Horizontal Blades

(3) "Rubbish," same defects as (2) but not so bad; (4) "Dead soft," balls that are covered with small pits caused by impact with hard balls during the process of tumbling; (5) "Out of round," balls known as "wigglers" by the inspectors; (6) "Fifth grade," balls with small cuts and scratches on them; (7) "Fourth grade," balls showing same defects as "Fifth grade," but not of so serious a character; (8) Balls having no defects sufficiently serious to be visible to the eye. The inspectors engaged in making the plate inspection are provided with small magnets somewhat the shape of a pencil with which they handle the balls with amazing dexterity.

A large majority of the balls come under the eighth classification, which includes those that show no visible defects while going through the plate inspection. Disposal of the defective balls varies somewhat according to their size. Many of the small balls with defects of the kind referred to are sold to various manufacturers, according to the class of service required of them. For instance, very poor balls are sold to novelty makers for uses already referred to. Other balls that are not good enough for use in high-grade ball bearings are plenty good enough for the use of certain manufacturers of hardware specialties, such as roller bearing castors for furniture, roller bearing roller skates, etc. Large balls that are found defective are returned to the manufacturing department, where they are ground down to a smaller size in order to remove the defects from the surface of the metal; and these balls are then carried through the regular process of manufacture, which has already been fully described.

Gaging Balls for Size

Balls that are used in annular bearings must be of absolutely the same size in order to give satisfactory results. If this is not the case, the large balls will support all the load, and the undue amount of service to which they will be subjected will cause them to be destroyed more rapidly than would otherwise be the case. In order to fit properly in the races, it is desirable for the balls to be of exactly the specified size, but provided all the balls are of the same size, they are capable of giving very satisfactory results even though they are either slightly over or under the specified size. In the final process of inspection, the balls are gaged and sorted out into different grades, according to whether they are of exactly the specified size or somewhat under or over this size. Attention is called to the fact that this variation in high-grade steel balls does not exceed a few ten-thousandths inch. As balls of the different grades are all of the same size, they are capable of giving perfectly satisfactory results. Some users of balls gage them at their own plants and make this subdivision, while others buy gaged balls ready for assembly.

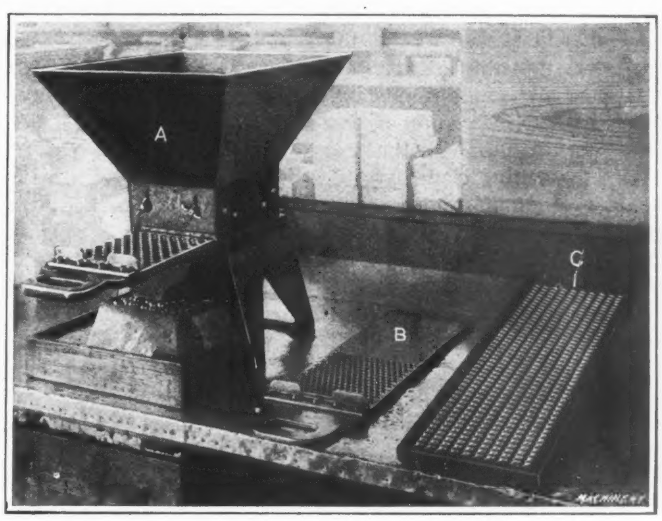


Fig. 28. Methods used for counting Balls preparatory to packing

In gaging those balls which show no defects in conducting the plate inspection, practice varies according to the size of the balls, but in all cases the object is the same, namely, to sort the balls out into those which are of absolutely the desired size and those which vary by different degrees either above or below the standard. Balls up to and including 5/8 inch in diameter are gaged on automatic machines which sort them into seven different grades, as follows: balls exceeding 0.0002 inch over size; balls 0.0002 inch over size; balls 0.0001 inch over size; balls of the specified size; balls 0.0001 inch under size; balls, 0.0002 inch under size; and balls more than 0.0002 inch under size. Automatic gaging machines are used for this grading, two batteries of such machines being shown in Figs. 25 and 26. The balls are placed in hoppers *A*, at the bottom of each of which there is a plate in which a number of holes are drilled in a ring, these holes being of slightly larger size than the balls to be gaged. The plates are revolved, and as each hole comes into line with the delivery tube, the ball carried in this hole drops into the tube and runs down over gage-blades *B* which are set at a slight angle to each other so that balls of the different sizes referred to will drop between the gage blades and enter tubes that carry them to the proper drawers in the cabinets beneath.

It will be seen that two types of machines are shown in Figs. 25 and 26. In Fig. 25 the gage blades are placed on an incline so that the balls run over them by gravity, and as the balls are always in contact with the gage blades, the tubes leading to the drawers of the cabinet can be placed much closer together than on the type of machine shown in Fig. 26, where the gaging blades are in a horizontal position. On the latter type of machine an agitator is necessary to keep the balls moving over the gage blades. This agitator consists of a crank *C* and connecting-rod *D* that actuates a link mechanism which causes a horizontal bar to rise in the space between the gaging blades. This bar rises slightly and then moves forward, carrying the balls with it, after which the agitator bar slowly drops and leaves the balls once more supported on the gaging blades. In this way the balls are moved along over successive tubes and finally drop through between the gaging blades—the position being determined by the size of the balls—so that different sizes of balls are sorted out as previously described. A stop checks the progress of the ball as it passes onto the gaging blades, and prevents it from rolling too fast. The gaging blades are set by master balls, in order to have the desired angle between them; and before the balls are packed, the accuracy of the blade setting is tested.

Special Indicator for Testing Balls

For gaging balls larger than 5/8 inch in diameter use is made of an instrument of the form shown in Fig. 27. This will be seen to consist of an ordinary Brown & Sharpe dial test indicator accurate to 0.0001 inch, that is set up on the table on which is also carried a holder for the ball to be tested. Connection between the ball and the dial test indicator is made by a lever, the fulcrum of which is so placed as to give a ratio of 1 to 10, and in this way readings obtained are accurate to 0.0001 inch. The girls who conduct this inspection handle the balls very rapidly and sort them out into different sizes according to the amount of deviation from the normal size.

Counting and Packing Balls

It is necessary to use great care in handling finished balls to prevent them from becoming rusty. On this account it would not do to have the balls touched by hand; but even if this were possible, to attempt to count the product of the Hoover Steel Ball Co. by hand would involve a prohibitive amount of time. For these reasons, several methods of mechanical counting have been developed which give extremely satisfactory results. The apparatus used for this mechanical counting is shown in Fig. 28. The balls are placed in hopper *A* and dropped down in holes in sliding plate *B*, which is pushed forward so that the holes are under the hopper during the "loading" period. The plate is then drawn forward to allow the balls to drop out into a box placed to receive them. Each stroke of the plate counts out one hundred balls, and plates for counting balls of various sizes are made interchangeable so that all of them may be used on a given machine. Balls up to 1/2 inch in diameter are counted by the machine, and balls from 9/16 to 7/8 inch in diameter are counted mechanically by means of board *C*, into the grooves of which the balls are loaded up to an index line. Plates of this kind are made for various sizes of balls, and each plate holds 500 balls. Large balls are counted by hand, care being taken not to touch the balls with the bare fingers. After counting, the balls are packed in cartons lined with waxed paper, and these are packed in substantial wooden boxes for shipment to the consumer.

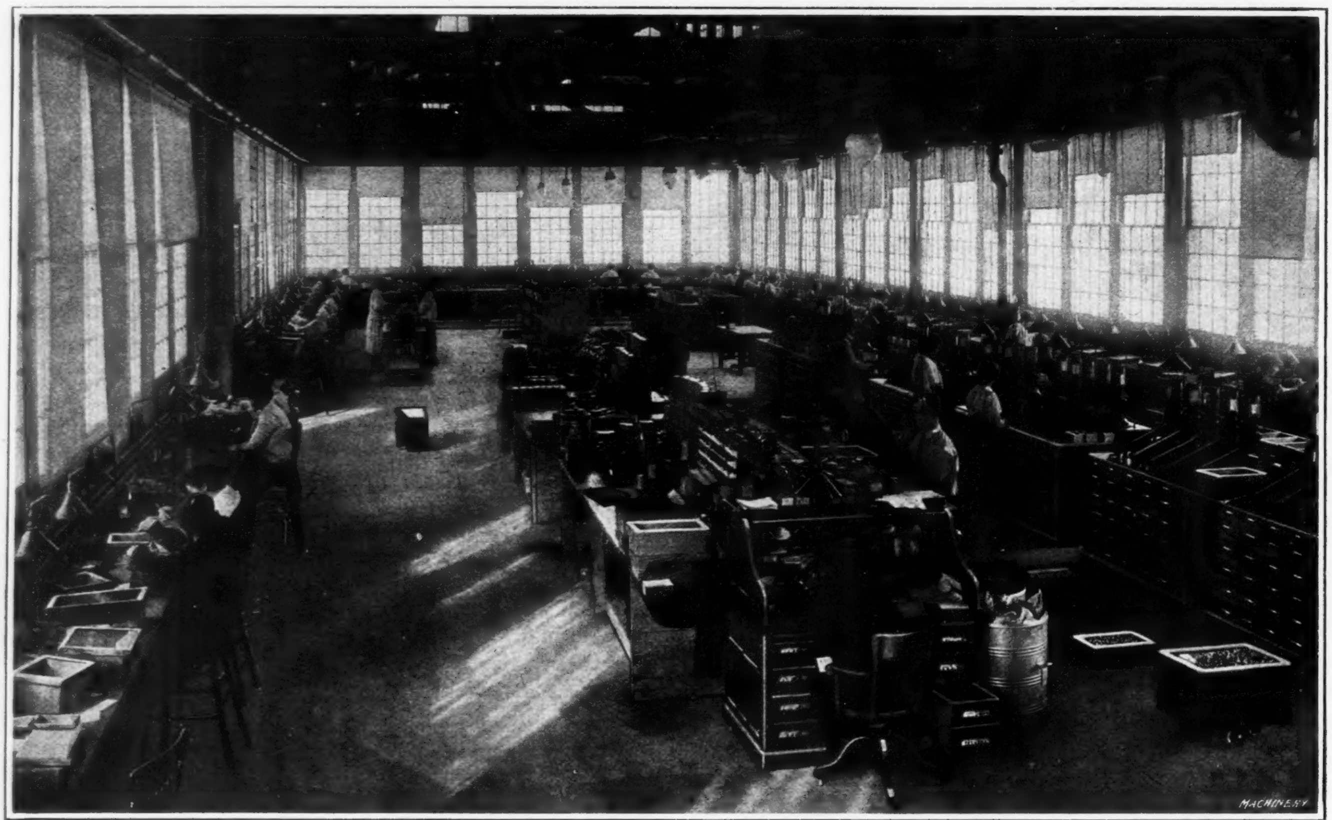


Fig. 29. General View of Room in Inspection Department, showing Different Forms of Equipment used for testing, counting and packing Balls

INTERNAL WORM-GEARING[1]

ADVANTAGES AND PECULIARITIES OF CONSTRUCTION—PROPORTIONS OF WORM THREADS AND GEAR TEETH—METHODS OF MAKING INTERNAL WORM-GEAR

BY REGINALD TRAUTSCHOLD[2]

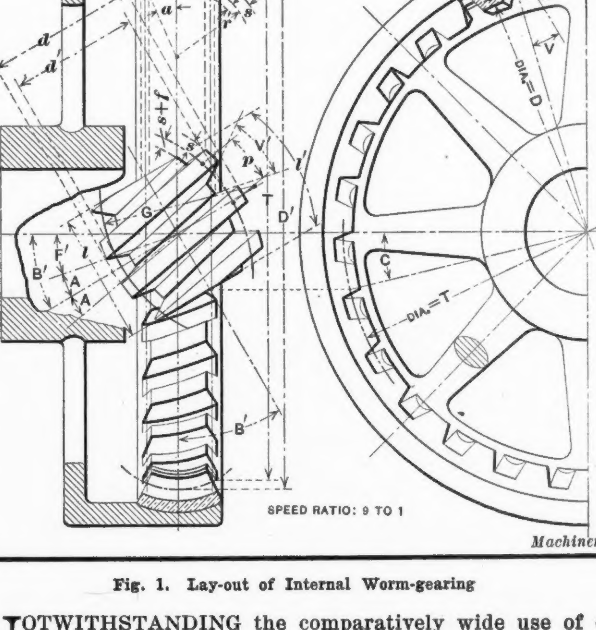


Fig. 1. Lay-out of Internal Worm-gearing

NOTWITHSTANDING the comparatively wide use of externally meshing worm-gearing with its possibilities for high speed ratios and its relatively high efficiency when properly designed and mounted—in spite of the popular belief that such gearing is inefficient—little or nothing has been done to develop and put to practical use worm-gearing of the internally meshing type. As the same advantages can be secured with internal worm-gearing (in fact, the advantages are somewhat greater, as internal worm-gearing is necessarily a modification of the efficient Lanchester worm construction) failure to use the internal worm can only be due to lack of knowledge as to its design and proper machining.

Fig. 1 shows a typical lay-out of worm-gearing and illustrates the two principal peculiarities of the construction: First, the worm and gear shafts, viewed from the back of the worm, must always lie in intersecting planes, that include an angle of greater than 90 and less than 180 degrees; and second, the worm is of the globoid form. The angularity of the shafts, most conveniently expressed in terms of the complement of the angle actually included between them (angle B') and termed the "shaft angle," cannot be 90 degrees ($B' = 0$ degrees), as is the common construction for externally meshing gears, on account of the impossibility of directly driving a worm so located. It should, however, be less than 180 degrees ($B' = 90$ degrees), for at such shaft angularity the worm would develop into an ordinary spiral pinion and require a driven gear with spiral teeth.

Derivation of Worm Formula

The globoid form of the worm depends on the angularity of the shafts, the diameter of the gear, and the face of the gear. Fig. 2 diagrammatically depicts the derivation of the formula for ascertaining the radius of longitudinal curvature to the pitch line profile of the worm, and also the "lay-out method" for arriving at the value of this dimension. The pitch outline of the worm is shown superimposed on the sectional pitch outline of the gear, the diagrams of the two members being their actual positions when viewed from above the parallel shaft planes. The length of the worm is arbitrarily fixed by the projections of the points u and v at which the axis of the worm would intersect the outer pitch lines of the gear. The line contact between the worm and the gear in any plane that includes the axis of the gear is evidently not the curve of the large pitch diameter d' of the worm, but the curve straddling the minor axis of an ellipse. This ellipse has a minor axis equal to the large pitch diameter of the worm and a major axis equal to the pitch diameter of the worm (large) divided by the cosine of the shaft angle B'; it is shown in dotted outlines, centered about the worm. The curve bounding the flattened sides of this ellipse, in the vicinity of its minor axis, is virtually an arc of a radius equal to the major axis of the ellipse minus one-half the large pitch diameter of the worm. This radius r' is that of the pitch surface of the gear in the radiating axis planes.

The pitch diameter on the edge of the gear T is then equal to the pitch diameter D' minus twice the difference between the gear face radius r' and the product of this radius by the cosine of half the angle a included by the slopes of the ends of the gear teeth. Points u, v, and w—the last the projection of the central contact point between the gear and pinion—lie on the contact curve between the gear pitch surface and the longitudinal pitch profile of the worm. An arc passing through these three points will closely approximate this contact curve. The radius of such an arc and the radius of the longitudinal pitch profile of the worm (see calculations in Fig. 2) is designated G and is equal to the length l of the worm divided by four times the product of the sine and cosine of the angle E included between the axis of the arc and its semi-chord. The sine of the contact angle of the worm C is equal to the product of the length of the worm and the cosine of the shaft angle divided by the pitch diameter of the gear at the ends of the teeth T.

Obliquity of Gear Teeth

Unless the angular pitch of the worm (the angular lead of the worm thread measured on the projection of the spiral

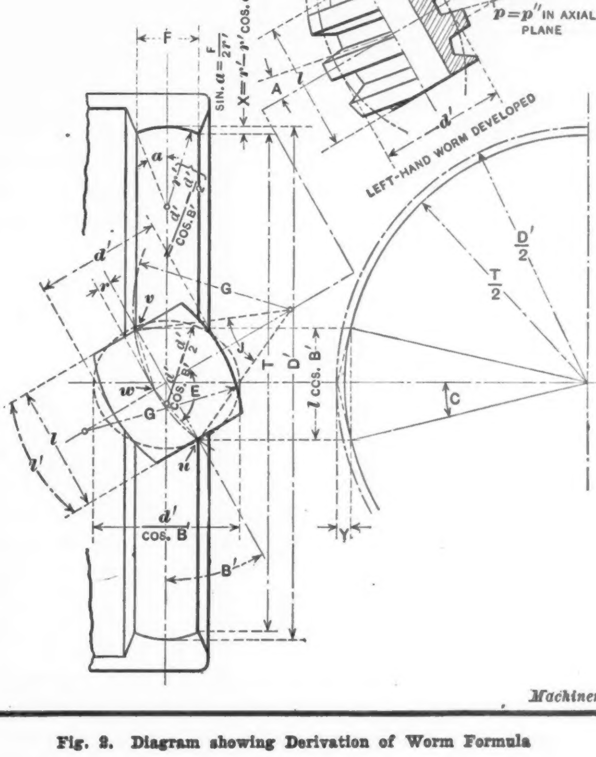


Fig. 2. Diagram showing Derivation of Worm Formula

[1] For articles on other types of internal gearing, previously published in MACHINERY, see "Internal Bevel Gearing," March, 1917, and articles there referred to.

[2] Address: 39 Charles St., New York City.

pitch line) that is, the angle A included between the projected pitch line and the central plane normal to the axis of the worm, and the shaft angle B' are the same, the gear teeth must cross the gear face obliquely. The angle of this gear-tooth obliquity depends on the shaft angle, the angular lead of the worm, the hand of the worm, and the hand of the drive. The hand of the drive is designated right or left as the shaft angle B' when viewed from the back of the worm, lies to the right or the left of the plane of the gear. The angular lead of the worm may be measured by an angle which is either less or greater than the shaft angle; that is, angle A may be less or greater than angle B'. With the possibility of the worm being either of the right-hand or left-hand variety, the drive right-hand or left-hand, and the angular lead of the worm either greater or less than the shaft angle, there are eight different arrangements of gear tooth obliquity, for each of which a simple relation exists between the various angles. These are shown in Figs. 3 to 10. The accompanying table gives convenient formulas for arriving at the value of either

GEAR-TOOTH OBLIQUITY

Arrangement	Angular Lead (Worm) A	Tooth Obliquity (Gear) F'
Fig. 3	$A = B' - F'$ (+)	$F' = B' - A$ (+)
Fig. 4	$A = F' - B'$ (—)	$F' = B' + A$ (+)
Fig. 5	$A = B' - F'$ (—)	$F' = B' - A$ (—)
Fig. 6	$A = F' - B'$ (+)	$F' = A + B'$ (—)
Fig. 7	$A = B' + F'$ (+)	$F' = A - B'$ (+)
Fig. 8	$A = F' - B'$ (—)	$F' = A + B'$ (+)
Fig. 9	$A = B' + F'$ (—)	$F' = A - B'$ (—)
Fig. 10	$A \quad F' - B'$ (+)	$F' = A + B'$ (—)

Machinery

the angular lead of the worm or the obliquity of the gear teeth for these eight arrangements. The hand of obliquity is designated as plus (+) for right hand and minus (—) for left hand.

Worm-thread Proportions

The normal cross-section of the worm thread establishes the shape and proportions of the gear teeth and is, of course, the conjugate of the gear tooth spaces. It is quite similar to an Acme female screw thread cut upon a pitch curve with a radius equal to twice the longitudinal pitch profile radius of the worm divided by the cosine of the angular worm thread pitch, minus the longitudinal pitch profile radius of the worm. Fig. 12 depicts the same pitch curve for the hob used in cutting the gear teeth.

The teeth, disregarding their position about a curved surface, are quite similar in shape and proportions to standard 29-degree involute rack teeth in normal section. The main difference is in the increased dedendum of the worm thread and in the proportions being based on the normal circular pitch. In the longitudinal plane of the worm, the effective section is heavier than the normal section and the obliquity of the sides of the threads is greater, the distortion depending on the angular lead of the worm. The longitudinal pitch of the worm, corresponding to the circular pitch of the gear but measured on an arc of smaller radius, is equal to the normal distance between threads, measured on the pitch surface of the worm, divided by the cosine of the angular lead of the worm.

Gear-tooth Proportions

As the teeth of internal worm-gears, like those of the ordinary type of externally meshing worm-gears, are most efficiently and expeditiously cut with a hob, the tooth spaces are proportioned to conform to the shape of the worm thread. That is, the gear teeth themselves are proportioned by the elimination of the tooth spaces. These tooth spaces are proportioned, proper allowance being made for clearance, etc., as are the worm threads. The gear-tooth section on the center plane of the gear (see Fig. 11) differs from the normal section of both the worm thread and the gear tooth and also from the longitudinal worm-thread section, the obliquity of the gear teeth and the angularity of the worm threads not being the same, as a rule. The pitch circle of the gear is measured by its pitch diameter, and the circular pitch is equal to the pitch circumference divided by the number of gear teeth. The width of the tooth space on the pitch circle is equal, of course, to one-half the circular pitch. The pressure angle of the gear teeth meshing with a worm with a standard 29-degree thread is measured by an angle having a tangent equal to the tangent of an angle of 14 degrees, 30 minutes divided by the cosine of the angle of gear-tooth obliquity.

In normal cross-section, the proportions of the tooth space more nearly conform to the normal section of the worm thread but differ in that the gashing of the tooth spaces is about a surface of lesser curvature than the curved profile surface of the worm. The normal pitch of the gear is equivalent to its circular pitch multiplied by the cosine of the angle of gear-tooth obliquity. The width of the tooth space on the pitch curve, which for each pair of adjacent teeth is approximately equal to an arc of a radius equal to the pitch diameter of the gear divided by the cosine of the angle of gear-tooth obliquity minus one-half the pitch diameter of the gear, is equal to half the normal pitch. The pressure angles of adjacent gear teeth include an angle of 29 degrees. The addendum of internal worm-gear teeth is the same as that of 14½-degree standard involute teeth of similar pitch and diameter; the other tooth proportions, the dedendum, clearance, etc., are also similar but for the slight increase in clearance that is provided to allow for wear.

Notation for Internal Worm-gearing

Speed ratio	R
Shaft angle	B'
Obliquity of gear teeth	F'
Angular lead of worm	A
Number of teeth in gear	N
Number of threads to worm	n
Circular pitch	p'
Normal circular pitch	p''
Longitudinal worm pitch	p
Angularity of sides of gear	a
Face of gear	F
Pitch radius of gear throat	r'
Pitch diameter of gear	D'
Pitch diameter at ends of gear teeth	T
Pitch diameter of worm (large)	d'
Effective pressure angle of gear teeth	V
Addendum	s
Clearance	f
Depth of teeth and worm threads	W
Inside diameter of gear	D
Outside diameter of worm (large)	d
Length of worm	l
Length of contact arc	l'
Longitudinal contact arc (gear)	C
Height of contact arc	Y
Contact angle (worm)	E
Longitudinal pitch profile radius of worm	G
Angular worm contact	J
Axial thread space angle of worm	V'

Formulas for Internal Worm-gearing

$A = B' + F'$ or $F' - B'$; $F' = B' + A$ or $A - B'$ (See table)

$$p' = \frac{3.1416\,D'}{N} \quad (1) \qquad p' = \frac{p''}{\cos F'} = p'' \sec F' \quad (1a)$$

$$p'' = p' \cos F' \quad (2) \qquad \operatorname{Sin} a = \frac{F}{2r'} \quad \text{(Usually } a = 30 \text{ degrees)} \quad (3)$$

$$r' = d' \sec B' - 0.5d' \qquad r' = F \quad \text{(When } a = 30 \text{ degrees)} \quad (4)$$

$$D' = Np'\,0.3183 \quad (5)$$

$$T = D' - 2(r' - r' \cos a)$$

$$T = D' - 0.2679F \quad \text{(When } a = 30 \text{ degrees)} \quad (6)$$

$$\operatorname{Tan} V = \frac{\tan 14 \text{ deg., } 30 \text{ min.}}{\cos F'} = 0.2586 \sec F' \quad (7)$$

$$s = p''0.3183 \quad (8) \qquad f = p''0.0650 \quad (9)$$

$$s + f = p''0.3833 \quad (10) \qquad W = p''0.7016 \quad (11) \qquad D = D' - 2s \quad (12)$$

$$d' = \frac{\sin a}{2r'(\sec B' - 0.5)}$$

$$d' = \frac{F}{\sec B' - 0.5} \quad \text{(When } a = 30 \text{ degrees)} \quad (13)$$

$$n = \frac{N}{R} \quad (14) \qquad d = d' + 2s \quad (15)$$

$$l = \frac{F}{\sin B'} \quad (16) \qquad \sin C = \frac{l \cos B'}{T} \quad (17)$$

$$Y = 0.5(D' - T \cos C) \quad (18) \qquad \operatorname{Cot} E = \frac{2Y}{l} \quad (19)$$

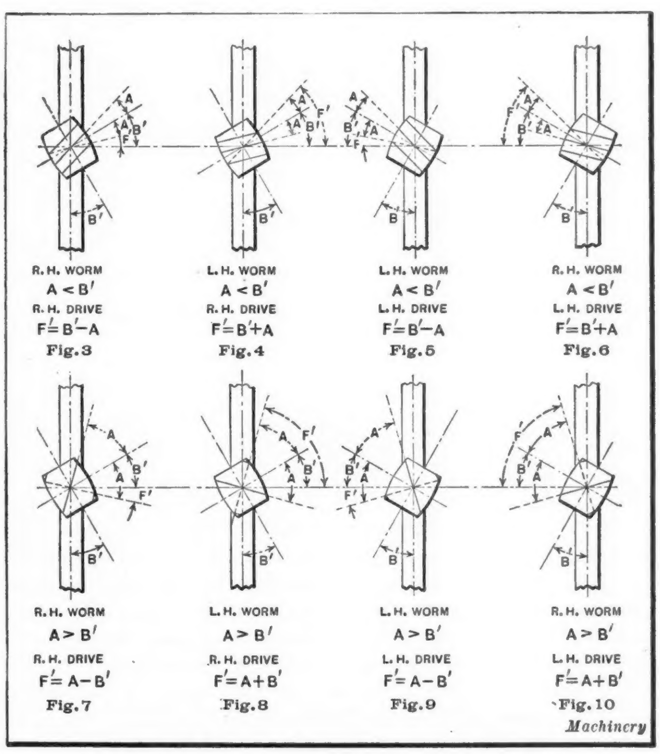
$$G = \frac{l}{4 \sin E \cos E} \quad (20) \qquad J = 360 - 4E \quad (21)$$

$$l' = \frac{3.1416GJ}{180} = 0.01745GJ \quad (22)$$

$$p = \frac{l'}{n} = \frac{p'D'}{2G \cos B'} \quad (23) \qquad R = \frac{N}{n} \quad (24)$$

Discussion of Formulas

The circular pitch is the quotient of the pitch circumference of the worm-gear divided by the number of teeth in the gear, or is equal to the normal circular pitch multiplied by the secant of the angle of obliquity of the gear teeth. It governs the diameters of the gear but it is in no way indicative of the strength of the teeth. The normal circular pitch, which is the criterion of the strength and wearing qualities of the gear teeth, and governs the proportions of the worm thread in effective section, is less than the circular pitch. It is the product of the circular pitch and the cosine of the angle of gear-tooth obliquity.



Figs. 3 to 10. Diagram depicting Gear-tooth Obliquity

The angularity of the sides of the gear (the ends of the teeth) is controlled by the pitch diameter (large) of the worm and the shaft angle; it is usually 30 degrees. A larger angle increases the face of the gear and aggravates wear through increased friction, and a smaller angle gives insufficient contact surface for efficient transmission of power. The arbitrary fixing of the angularity of the sides at 30 degrees enables a number of the design formulas to be greatly simplified and made more adaptable for accurate computations.

The pitch radius of the gear throat is dependent on the pitch diameter of the worm and the shaft angularity, being the contact line, in the plane of the gear's axis, between the inclined worm and gear. This radius, when the angularity of the sides of the gear is 30 degrees, equals the face of the gear, a dimension that is customarily chosen arbitrarily or is fixed by the amount of power to be transmitted by the gearing.

As the gear teeth cross the gear face obliquely, the pressure angle of the teeth in the plane of the gear is obtained from its tangent. This tangent is equal to the tangent of the normal

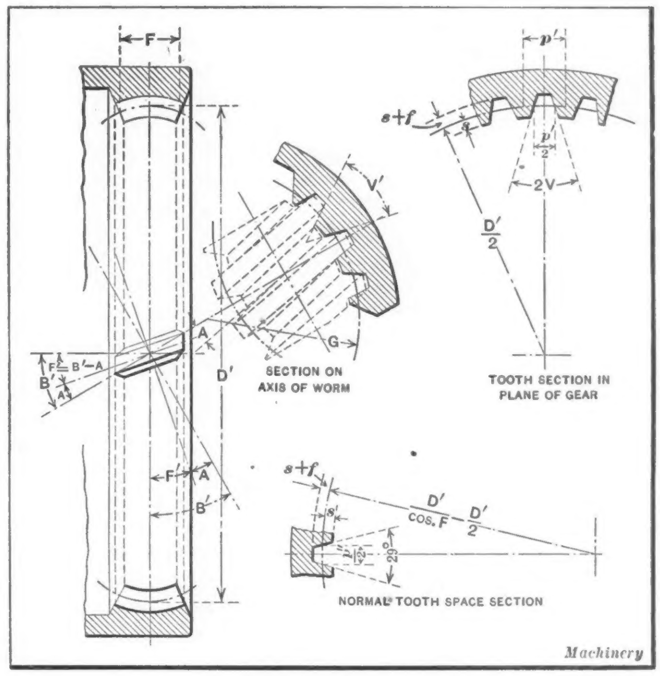


Fig. 11. Gear-tooth Proportions

pressure angle (which is usually 14 degrees, 30 minutes) divided by the cosine of the angle of obliquity of the gear teeth.

The clearance allowed in worm-gearing is customarily greater than is allowed in gearing operated through rolling contact. This increase is arbitrarily taken as equal to p'' 0.015. The addendum and dedendum are calculated from the normal circular pitch, not from the circular pitch. The increase does not affect the addendum but does enlarge the dedendum and the whole tooth depth dimensions.

Inasmuch as the angularity of the sides of the gear and the pitch radius of the gear throat are controlled by the large pitch diameter of the worm, there is a fixed relationship between the large pitch diameter of the worm and the factors that it controls. The general formula for the large pitch diameter of the worm is the sine of the angle of the sides of the gear divided by the product of twice the pitch-radius of the gear throat by the secant of the shaft angle minus 0.5. By making the angularity of the sides of the gear equal to 30 degrees, the formula is simplified to the gear face divided by the secant of the shaft angle minus 0.5.

The necessary number of simple threads to the worm is most easily found by dividing the number of teeth in the gear by the required speed ratio. Preferably the number of threads should be a whole number, but this is not absolutely necessary, for any number, mixed or whole, of complete threads may be employed. A mixed number of threads, however, complicates the checking up of the worm. The length of the worm is controlled by the shaft angle and should be made equal to the face of the gear divided by the sine of the shaft angle. A shorter worm will not develop the full efficiency of the con-

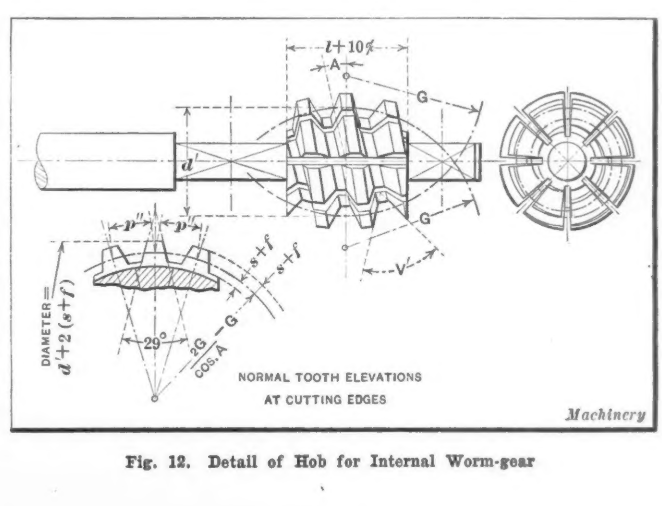


Fig. 12. Detail of Hob for Internal Worm-gear

struction and a longer worm will not be effective over the added length.

The longitudinal contact arc on the pitch circumference of the gear, measured by the sine of the angle included between the projection of the semi-chord of the arc and its center axis, is equal to the projection of the normal contact curve on the pitch circumference divided by the pitch diameter of the ends of the gear teeth. The height of this arc, also the height of the normal contact arc, is equal to one-half the difference between the pitch diameter of the gear and the product of its pitch diameter at the ends of the teeth by the cosine of the angle measuring the longitudinal contact arc of the gear. The cotangent of the contact angle E (see Fig. 2) is then equal to twice the height of the contact arc divided by the length of the worm and the radius of the arc is equal to the length of the worm divided by four times the product of the sine and cosine of the angle of the contact arc E.

The angle included by the contact arc, or the angular worm contact, is equal to 360 degrees minus four times the contact angle E, from which the length of the contact arc is readily obtained by direct proportion, the longitudinal pitch profile radius of the worm being known.

The longitudinal worm pitch, or the distance between centers of threads measured on the pitch arc, obviously equals the length of the contact arc divided by the number of threads to the worm. It is also equal to the product of the circular pitch of the gear and its pitch diameter divided by twice the product of the longitudinal pitch profile radius of the worm by the cosine of the shaft angle.

Example in Design of Internal Worm-gearing

Example:—Required, an internal worm-gear combination; 48 teeth in gear; speed ratio, 12 to 1; right-hand worm; right-hand drive; 1 inch circular pitch; angle of sides of gear teeth, 30 degrees; shaft angle, 30 degrees; angular lead of worm, + 15 degrees; and face of gear, 3 inches. That is, $B' = 30$ degrees, $A = 15$ degrees, $a = 30$ degrees, $N = 48$, $F = 3$ inches, $p' = 1$ inch, $R = 12:1$.

$F' = 30 - 15 = +15$ degrees (arrangement Fig. 3, from table)

$$p'' = 1 \times 0.96593 = 0.966 \text{ inch} \quad (2)$$

$$r' = 3 \text{ inches} \quad (4)$$

$$D' = 48 \times 1 \times 0.3183 = 15.2784 \text{ inches} \quad (5)$$

$$T = 15.2784 - 0.2679 \times 3 = 14.4747 \text{ inches} \quad (6)$$

$$\text{Tan } V = 0.2586 \times 1.0353 = 0.26773 \quad (7)$$

$$V = 14 \text{ degrees, } 59 \text{ minutes}$$

$$s = 0.966 \times 0.3183 = 0.3075 \text{ inch} \quad (8)$$

$$f = 0.966 \times 0.0650 = 0.0628 \text{ inch} \quad (9)$$

$$s + f = 0.966 \times 0.3833 = 0.3703 \text{ inch} \quad (10)$$

$$W = 0.966 \times 0.7016 = 0.6777 \text{ inch} \quad (11)$$

$$D = 15.2784 - 2 \times 0.3075 = 14.6634 \text{ inches} \quad (12)$$

$$d' = \frac{3}{1.1547 - 0.5} = 4.582 \text{ inches} \quad (13)$$

$$n = \frac{48}{12} = 4 \quad (14)$$

$$d = 4.582 + 2 \times 0.3075 = 5.197 \text{ inches} \quad (15)$$

$$l = \frac{3}{0.5} = 6 \text{ inches} \quad (16)$$

$$\text{Sin } C = \frac{6 \times 0.86603}{14.4747} = 0.3589 \quad (17)$$

$$C = 21 \text{ degrees, } 2 \text{ minutes}$$

$$Y = 0.5\ (15.2784 - 14.4747 \times 0.93337) = 0.88407 \text{ inch} \quad (18)$$

$$\text{Cot } E = \frac{2 \times 0.88407}{6} = 0.29469 \quad (19)$$

$$E = 73 \text{ degrees, } 35 \text{ minutes}$$

$$G = \frac{6}{4 \times 0.95923 \times 0.28262} = 5.533 \text{ inches} \quad (20)$$

$$J = 360 - 4\ (73 \text{ degrees, } 35 \text{ minutes}) = 65 \text{ degrees, } 40 \text{ minutes} \quad (21)$$

$$l' = 0.01745 \times 5.533 \times 65.666 = 6.340 \text{ inches} \quad (22)$$

$$p = \frac{6.340}{4} = 1.585 \text{ inch} \quad (23)$$

The Hob

The outside diameter of the hob for cutting the gear teeth must be equal to the outside diameter of the worm plus twice the clearance; the increase in diameter usually provided for the hobs of ordinary externally meshing worm-wheels to allow for wear should also be provided. That is, the addendum and dedendum dimensions of the hob should be made the same, the increase in diameter being the same as the increase in the clearance allowed for the gear and worm. The length of the hob should be about 10 per cent greater than that of the worm employed in driving the gear to be cut, in order to insure a gradual bite into the metal of the worm-wheel without danger of marring the edges of the completed gear teeth, the cutting teeth of the hob engaging the edges of the gear face before the mid-tooth section.

The proportions of the hob teeth on the normal cutting planes (see Fig. 12), with the exception of the elongated addendum and the corresponding increase in their length, are similar in every respect to those of the worm thread and require no explanation. The draft and clearance of the hob teeth, however, are of the utmost importance. The normal pitch curve radius for each individual tooth of the hob, like the corresponding radius for the worm, equals twice the longitudinal pitch profile radius divided by the cosine of the angle of the angular thread (tooth) pitch minus the longitudinal pitch profile radius. This pitch curve radius, common to the hob and the worm, is that of the curve of the flattened sides of an ellipse with a minor axis equal to twice the pitch profile radius and a major axis equal to the minor axis divided by the cosine of angular worm lead.

Machining Internal Worm and Hob

The worm and hob are machined in the same manner, the same, or similar cutting tools being employed. No special equipment is ordinarily required for the lathe, other than a

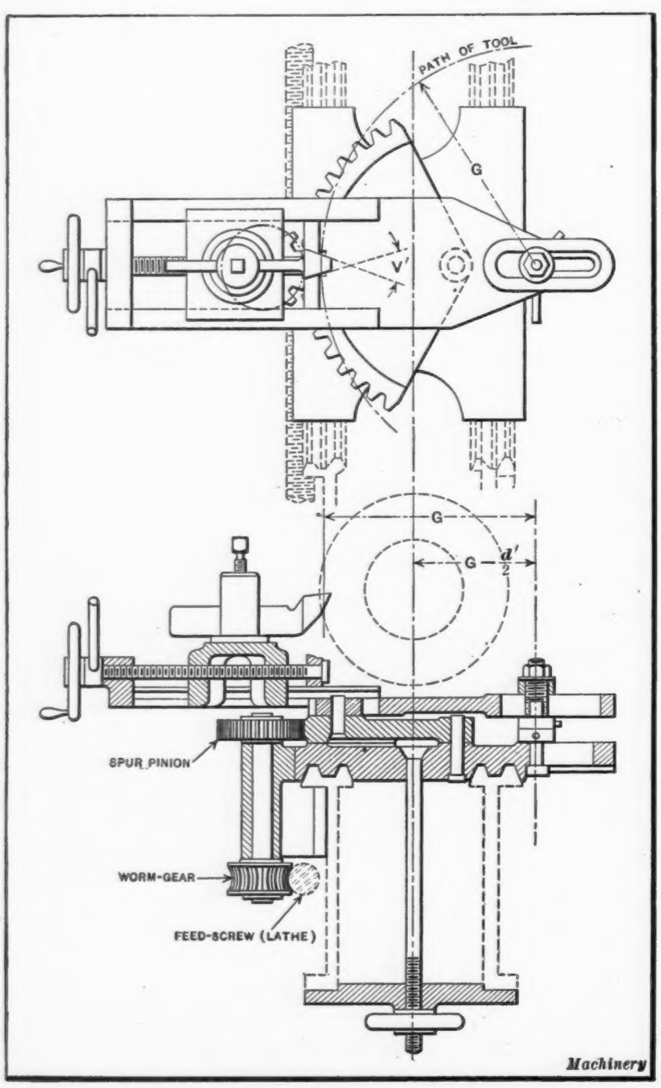


Fig. 13. Special Fixture for cutting Internal Worms and Hobs

radius link—conforming in length to the longitudinal pitch profile radius of the worm or hob—for guiding the cutting tool about the face of the worm. The pivot end of the link is fixed, in relation to the lathe bed, in the normal central plane of the worm, while its swinging end carries the toolpost, etc., the cross-feed being located on the link. The cutting tool is ground to conform not to the normal thread space but to the thread space in an axial plane, that is, angle V', and extreme care should be exercised to see that the angle between the sides of such space is the same for the worm as for the hob used in cutting the mating gear. As in all cases where a cutting tool is made to conform to an axial space that differs in form from the normal section of the gash cut, adequate clearance for the cutting tool must be provided.

A slight variation in the angularity (obliquity) of the threads cut at the center of the worm or hob and that of those cut toward the ends of the worm cannot be avoided in this method of guiding the cutting tool about the face of the worm, for the carriage travel along the lathe bed—actuated by the feed-screw of the lathe—must necessarily be at a constant speed. With the path of the cutting tool the arc of a circle, the cutting tool must travel farther than the distance along the lathe bed covered by the carriage in its journey from end to end of the worm. The travel of the cutting tool is measured by the arc of the longitudinal profile curve of the worm, while the travel of the carriage is only the axial length of the worm; the relationship of the paths is as l' to l. Hence, the circumferential feed of the tool must be gradually increased as it passes the normal center plane of the worm and must be retarded as it approaches the center of the worm. The increased circumferential feed of the cutting tool toward the ends of the worm increases the obliquity of the end threads, the increase in obliquity being gradual toward either end. This slight increase in the angularity of the threads at the ends of the worm and hob proves somewhat of an advantage when the gearing is first put into operation.

Should the worm be unusually long, however, some special fixture is necessary, for the difference between the circumferential and axial lengths of the worm will otherwise cause considerable variation in the obliquity of the worm thread, particularly if the radius of profile curvature is comparatively short, as would probably be the case. However, this method can be used for almost any length of worm, the difference in length of the operating arcs of the two swinging segments being much less than the difference in the lengths of the operating paths of the carriage and of the cutting tool in the "radius-arm method."

The special fixture shown in Fig. 13 can be used with any lathe of suitable swing. It is automatically actuated by the regular feed-screw of the lathe and consists essentially of two swinging segments pivoted to a supporting base clamped firmly to the lathe bed. The feed-screw engages the operating worm-gear of the fixture, which, in turn, drives a spur pinion meshing with the toothed edge of the lower of the two swinging segments. This toothed segment, which is a sector of a gear of the same pitch as the driving pinion and a pitch radius closely approximating the average longitudinal pitch profile radius of the worms and hobs suitably proportioned for the fixture, carries a driving pin that fits into a sliding wearing block in the upper swinging segment and causes the latter to swing about its pivot center as the toothed segment is shifted by the screw of the lathe. The upper segment carries the tool carriage and, with the distance of the cutting end of the tool from the pivot center of the upper segment set to correspond with the longitudinal pitch profile radius of the worm or hob, the path of the cutting tool follows the profile curve of the blank, being carried from end to end of the work at such a speed that the obliquity of the groove cut conforms to the angular lead of the worm thread.

A slight variation in the angularity of the threads cut at the center of the worm or hob and that of those cut toward the ends of the worm cannot be avoided with this type of guiding fixture, unless the pivot radius centers of the two segmental parts of the fixture are the same. A fixture designed on such lines would have a very limited capacity. A special fixture would be required for cutting each worm or hob of differing longitudinal pitch profile ra ius, pitch diameter or variation in ratio of longitudinal pitch profile radius to pitch diameter. A particular fixture for each worm cut would materially complicate the question of necessary equipment for manufacturing internal worm-gearing, though simplifying the type of fixture that could be used. By making the toothed segment pivot radius slightly different from the average longitudinal pitch profile radius of the worms for which the fixture is proportioned, an appreciable amount of adjustment can be made so that worms of varying size, etc., can be cut with the same fixture, and at the same time the variation in the rate of feed of the cutting tool, due to the non-concentricity of the two swinging segments, remains very slight. The variation in the rate of feed of the cutting tool would be almost negligible and might be a slight acceleration at the ends of the worm or hob or a gradual retardation in feed.

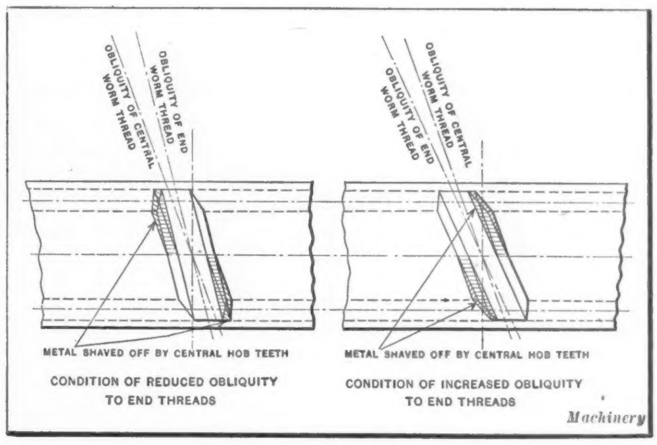


Fig. 14. Correction of Gear-tooth Obliquity by Central Hob Teeth

Machining Internal Worm-gear

Cutting the gear teeth with the globoid form of hob presents even less difficulty than hobbing the ordinary externally meshing type of worm-wheel, when the gear blank has once been correctly located in reference to the hob, and the shaft angle is accurately set. The worm-gear must be driven at the proper lead by an independent set of gears and at a speed commensurate with the speed at which the hob is driven; that is, the relationship between the speeds of the hob and the gear blank must be the same as that between the worm and the gear when in operation. With the gear blank and hob properly mounted, etc., a light cut is first taken to locate the spacing of the gear teeth correctly. The locating gashes are made along the face edges of the gear with the end teeth of the hob, as the outside radius of the hob is greater than the inside radius of the gear face in the plane of contact. The obliquity of the gashes differs slightly from that of the mid-tooth section later cut by the central teeth of the hob, on account of the method employed in cutting the hob. As the depth of the cut is increased and the central cutting teeth come into play, however, the obliquity of the teeth is correctly cut at mid-section and the obliquity at the ends gashed out by the end teeth of the hob corrected on one side of the tooth space. The side of the teeth corrected for obliquity depends upon the relationship of the radius of the toothed segment of the special fixture used in cutting the hob to the pivot radius of the cutting tool used—the longitudinal pitch profile radius of the worm.

When the radius of the toothed segment is slightly longer than the effective tool-carriage pivot radius, the obliquity of the end hob teeth is very slightly less than that of the central cutting teeth; this results in a trivial retardation of the feed of the cutting tool as it approaches the ends of the worm and hob. Should the longitudinal pitch profile radius—the effective tool-carriage pivot radius—be the longer, on the other hand, there will be a slight increase in the obliquity of the end threads and a corresponding increase in the feed of the cutting tool at the ends of the worm. The obliquity correction by the central hob teeth is to shave off one side of each tooth, the amount of metal removed increasing from the center of each tooth to the end, the removal of metal alternating from

end to end of tooth as graphically depicted, on an exaggerated scale, in Fig. 14.

Effect of Shaving Teeth on Tooth Action

The effect of thus removing a slight amount of metal from alternate semi-lengths of the sides of each gear tooth is to provide a very slight clearance for the initially engaging worm thread. This clearance, either in advance of or behind the worm thread, is negligible when the central threads of the worm come into action, and is effectively concentrated on the sections of the gear teeth in intimate contact with the end worm threads. These end worm threads actually transmit but a very small proportion of the power delivered and are more valuable as pilots for the proper engagement of the central worm threads than for the small amount of power they may transmit. The heavy pressure of the worm is thus gradually shifted from end to end of the gear teeth, resulting in a much smoother operation of the gearing while new. The tooth action is improved for new gearing, without in any way detracting from the smooth action of older gears that have become slightly worn. This is particularly so if the wear has been equal on both the worm threads and the gear teeth, a requisite for the satisfactory operation of any type of worm-gearing.

* * *

LOYALTY

BY J. P. BROPHY [1]

The editorial in the February number of MACHINERY entitled "Building Up an Organization" is interesting, but I do not altogether agree with the ideas expressed. The editorial says:

> The manufacturing concerns that have achieved a reputation for square dealing and general reliability are those which by years of effort and training have built up an organization of efficient and loyal employes.

The last two words, "loyal employes," I am sorry to say, do not mean very much to me. Loyalty is supposed to mean a generous amount of good feeling nearly approaching love for those to whom you are loyal. It might be supposed that any man in your employ from five to twenty years, who has been well treated in every respect, must be satisfied with his job or he would not remain so long, and should be considered loyal. If, as an employer, you have always considered the employe's comfort to the best of your ability, treating him with due consideration to the extent of having the surroundings as comfortable as possible and guarding against any unjust treatment by those in power, you certainly would expect some returns in fair treatment when the opportunity presented itself; not that you would expect more work from the old employe than from the man who has been employed, say, for a few months, but when trouble arises in the factory, you would think that the old-time employe would do the fair thing and not be carried away by the arguments of men who are here today and somewhere else tomorrow. From my experience during the last few years, I have become convinced that loyalty is rarely ever found in those in whom you would naturally expect it. In my estimation, if you have 5 per cent of actually loyal employes, you are lucky, regardless of whether you employ 50 or 5000.

Building up an organization is all right, and can be done as far as efficiency is concerned, because this is controlled by good management, but loyalty cannot be considered to go hand in hand with efficiency. The foregoing extract is nicely worded and will be read by many who will be much interested in it. However, I have never found loyal employes in abundance. They usually keep under cover and certainly do not act when the time arrives to defend the company that has employed them for a number of years. Of course, in any line of business, large or small, there are generally some loyal men. But, if you will consider what loyalty really means, I think you will agree that the human element crops out in most employes and results in actions that are detrimental to the employer.

Loyalty to country is certainly expected and should be demanded, but loyalty in the work-shop is a different proposition. The word loyalty looks good in print and it is a fine thing when lived up to. When two men can speak freely to each other on almost any subject, feeling safe in so doing, the ideal condition exists and one to be cherished through life. As already stated, we, and thousands of others, have tested the matter of loyalty many times, in our business troubles, and have found it a farce. It is well to be cautious to whom you speak confidentially in trying times. The risk is great and the damage irreparable in many instances. When it is too late, you will ponder and try to solve the problem. Old employes should consider their company's welfare, but many men lack the courage. There is a sneaky attitude noticeable, especially if it means the gain or loss of a few dollars; and when money is involved many employes are not dependable. It is regrettable for me to have to speak so plainly on this subject; it would be a gratification to take the opposite point of view.

If you, Mr. Editor, have not had these experiences, you are lucky. You will probably not escape this unpreventable shock that hardens every tender feeling you ever entertained for your men. If your nature is of the forgiving type, you may pass through life making excuses for those who prove treacherous rather than loyal. I am not trying to destroy the belief that loyalty exists in this world of ours; sometimes it is found where least expected. It does seem impossible that a vast number of old employes with whom you come in contact constantly could be anything but loyal.

Another paragraph in the editorial says that we should educate a certain percentage of our employes each year in the elements of the trades, as that practice is necessary to insure against strikes and labor troubles. I emphatically and without hesitation make the statement that if those who have had labor troubles were not afraid to speak their minds, they would testify that such practice will not be an insurance against strikes. No matter what you do or how you do it, can you for one moment feel safe when you have labor troubles. Even your old employes who should be considered old friends will desert you. It is exceptionally distasteful for me to have to express myself so forcibly on a subject of such great importance, but in all the strikes and labor troubles I have ever had to contend with, I have discovered, in many instances through being on the alert, that there were few men in the employ of the company I represented that showed the slightest inclination, regardless of how long they had been employed, to say one word in favor of the company. A great number of men whom I thought the most trustworthy have proved the reverse. It made no difference whether there was any justification in these labor troubles or not, the majority of the men proved to be the opposite of what should be expected, considering the length of time they were with the company and the manner in which they were treated for many years. Loyalty is like radium, extremely difficult to find and almost priceless when discovered.

[1] Vice-president and General Manager, Cleveland Automatic Machine Co., Cleveland, Ohio.

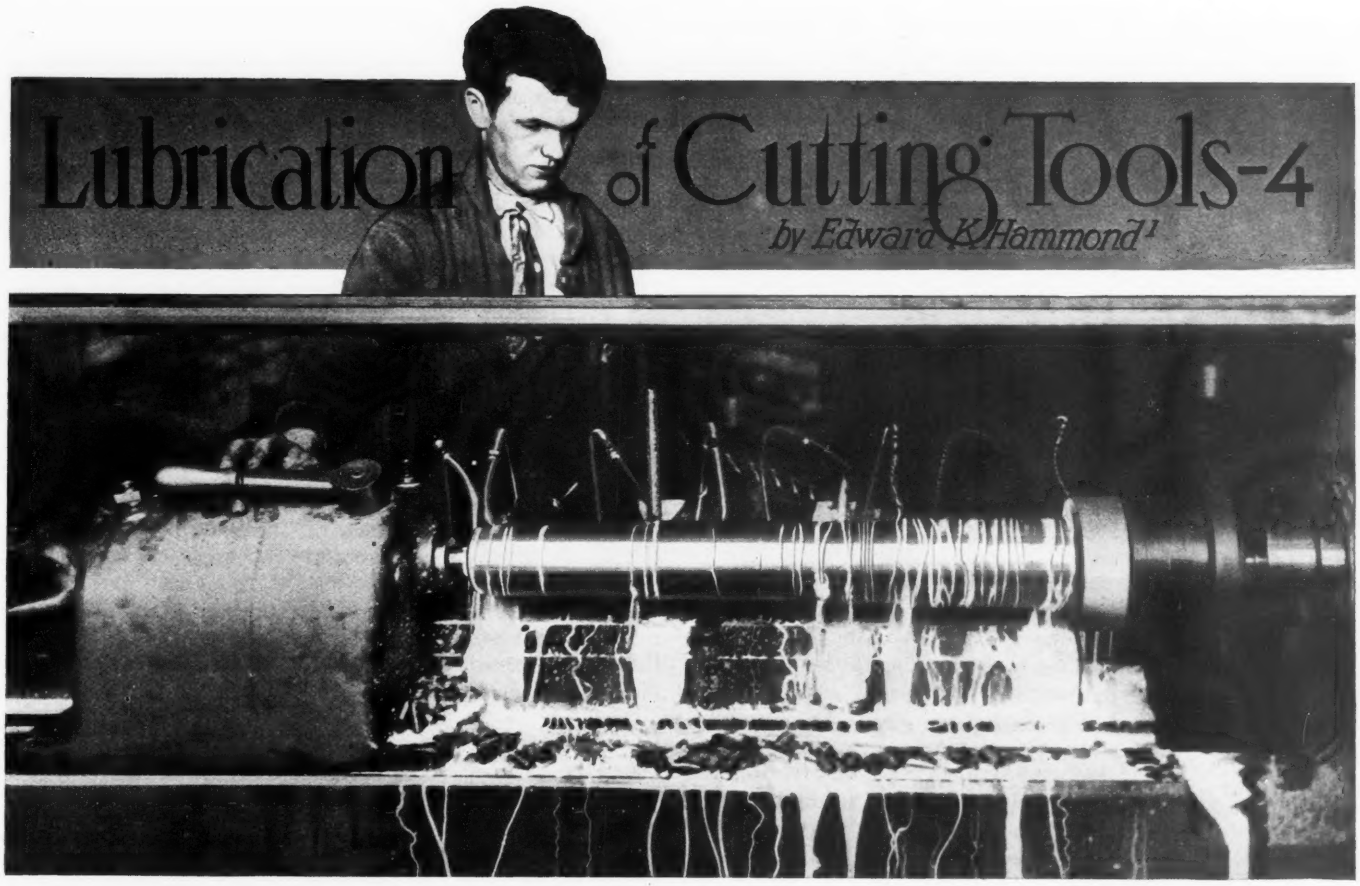
* * *

The New York Connecting R. R.—Hell Gate Bridge Route—for through passenger service between New England and the West and South, was dedicated to the service of the public by Samuel Rea, president of the Pennsylvania R. R. Co. March 9. The special train which conveyed the inspection party and which was the first train operated over the new link, left the Pennsylvania Station, New York City, passed through the East River tubes to the Sunnyside Yards, Long Island, then traversed the line of the New York Connecting R. R. to the northern end of Hell Gate Bridge, and thence proceeded to the junction of the New York, New Haven & Hartford R. R. in the Bronx. Gustav Lindenthal, designer of the Hell Gate Bridge and chief engineer of the East River Bridge Division, stated in his address at the dedication, that the project has cost over $27,000,000. It completes the car rail connection *via* New York City, between the Pennsylvania and New Haven systems, and consists of a four-track elevated line about six miles in length built of concrete and steel, which joins the New York, New Haven & Hartford R. R. with the lines of the Pennsylvania R. R. system, by way of the East River tubes, the Pennsylvania Station in New York City, and the Hudson River tubes. It makes possible through train service from all points in New England to Philadelphia, the West and the South. The Hell Gate Bridge is a single 1000-foot span supported by a double arch of steel across the East River.

R.

Lubrication of Cutting Tools-4

by Edward K. Hammond[1]



REFERENCE has been made in a previous installment to the diversity of practice which exists in the lubrication and cooling of metal cutting tools, and it was pointed out that this is largely due to numerous variable factors entering into the action of an oil or cutting compound which make it difficult to determine exactly the nature of the service performed by the fluid. When one manufacturer is using a soluble cutting compound costing, say, two cents a gallon, and another manufacturer uses petroleum oil costing twenty-four cents a gallon for the same purpose, it would appear that the latter practice involves unnecessary expense, and possibly this is the case. But the difference may not be as marked as a mere comparison of cost makes it appear, owing to the fact that the oil may wear longer and may enable the cutting tools to be operated for a greater length of time before they require grinding; or the work may be improved in quality and the wear of machine-tool equipment decreased.

A careful investigation of practice in representative American manufacturing plants goes to show that there are particular classes of work in which each of the commonly used cutting lubricants gives exceptionally good service, and a discussion of this subject will be presented to supplement the tabulated data in Table IV. Briefly, this information may be summarized as follows: Pure lard oil is one of the most efficient lubricants available, but owing to its high price, which is slightly in excess of $1 per gallon under present market conditions, the use of this lubricant undiluted is not generally recommended except for such machining operations as tapping, reaming, and similar classes of work where a high finish and great accuracy are required. In many such cases it has been found impossible to find a satisfactory substitute.

For automatic screw machine work some manufacturers still use pure lard oil, but here the need of a large volume of oil causes the question of economy to play an important part; as the so-called "mineral lard oil" mixtures, ranging from 30 per cent of lard oil and 70 per cent of medium petroleum oil up to equal parts of lard oil and petroleum oil, have been found to give practically as good results as pure lard oil, it seems desirable to use these mixtures. Furthermore, mineral lard oil has an advantage over pure lard oil in that it is more fluid and thus runs more freely to the tool and work; also, this mixed oil is not so likely to give trouble from gumming. Lard oil possesses a peculiar unctuous property that is not found in other oils, and it is a matter of common experience that trouble is likely to develop on automatic screw machine work—particularly in cases where forming, threading and tapping operations have to be performed—unless the lubricant used contains lard oil as one of its constituents.

Mineral lard oil mixtures are used for automatic screw machine work and for numerous other machining operations, and the following mixtures have been found highly satisfactory: (1) Equal parts of lard oil and petroleum machine oil. (2) Lard oil, 30 per cent, and mineral oil, 70 per cent. (3) On Cleveland automatic screw machines for cutting steel of different grades, from 10 to 12 per cent pure lard oil and 88 to 90 per cent neutral mineral oil of about 32 degrees Bé. gravity. The fluidity of this mixture permits it to reach the extreme cutting point of the tool and it possesses sufficient viscosity to form the required film on the work. (4) One part lard oil and three parts Pennsylvania petroleum oil. (5) Mineral lard oil reduced with from 33 1/3 to 66 2/3 per cent kerosene or paraffin. (6) Ten gallons lard oil to one gallon kerosene. (7) For drilling, reaming and gear planing, 30 per cent lard oil and 70 per cent petroleum.

With the view of reducing the cost of lubricants, some manufacturers have resorted to the use of pure petroleum oil on such machining operations as milling and turning, which seems to be a step in the direction of economy that is justified, because the mineral oil is giving satisfactory service. A further step in reducing the cost was made through the introduction of the so-called soluble oils and compounds used with water to form the well-known white cutting emulsions which are available at prices ranging from about 1½ to 15 cents a gallon, according to the degree of dilution. Opinion is divided in regard to the advisability of using these water emulsions,

[1] Associate Editor of MACHINERY.

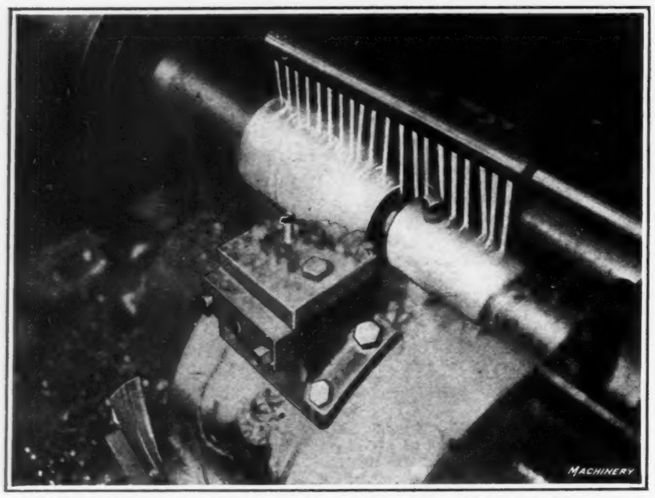


Fig. 78. Pipe with Series of Holes to distribute Coolant to Tools on Shell Turning Lathe

but the following seems to be representative of experience in shops where the question has received most careful consideration. For milling, drilling, grinding and other operations where short chips are produced, making cooling the most important service performed by the fluid, these water emulsions give very satisfactory results. They flow freely, and as water has a higher specific heat than any of the oils, these emulsions are more efficient than oil for cooling. In cases where lubrication of the tool is also important, it is good practice to add more of the soluble oil or paste compound in mixing the emulsion than where cooling only is necessary; but under the most favorable conditions these emulsions have but a slight lubricating action, so that they are unsuitable for use where long chips are produced. In such cases, some kind of oil will give more satisfactory results.

It has been a matter of fairly general experience that the soluble oil compounds are unsuitable for use on automatic screw machines, turret lathes and other machines having slides and bearings into which the emulsion can easily find its way. When fluids containing water are used on machines of this kind, the detergent action is a source of trouble because the oil is washed out of the bearings, and serious wear results.

The preceding is a brief summary of experience with the use of pure lard oil, mineral lard oil, pure mineral oil and soluble cutting compounds, which are the four classes of lubricants used on the majority of the cutting tools in American factories. Detailed information is given in the following paragraphs concerning the lubricants used for typical machining operations on different kinds of metal. In each case the recommendations are presented in the order in which these different lubricants are generally used. To supplement this information, Table IV gives lubricants that are more commonly employed for various machining operations on different classes of metal; and Table V gives a list of soluble oil compounds and their manufacturers, together with the degree of dilution recommended by these manufacturers for different classes of machining operations. In addition to the soluble compounds there are a number of commercial oil mixtures on the market; some of these are used "straight" while others are diluted with kerosene, fuel oil, etc. Table VI gives recommendations in regard to the classes of work for which these are adapted and the degree of dilution recommended for different classes of work.

General Lubricants for Different Machining Operations

In attempting to make recommendations for lubricants for various machining operations on different classes of metals, letters were sent out to a list of representative builders and users of different types of machine tools, asking them to furnish information concerning the lubricants and coolants they had found most satisfactory. Information obtained from these sources was supplemented by the observation of MACHINERY's editors while visiting manufacturing plants engaged in a great variety of work. When these data were analyzed it

TABLE IV. CUTTING LUBRICANTS FOR MACHINING OPERATIONS ON DIFFERENT CLASSES OF MATERIAL[1]

Operation	High-carbon and Alloy Steel	Low-carbon Steel	Cast Iron	Wrought Iron	Malleable Iron	Brass	Bronze	Copper	Aluminum	Monel Metal
Turning	Mineral lard Compound	Compound Dry	Dry	Dry Compound	Dry Compound	Dry	Dry	Dry	Kerosene	Dry Compound
Forming	Mineral lard Paraffin oil 28° Bé.	Mineral lard Compound	Dry	Dry Compound	Dry Compound	Dry	Dry	Dry	Kerosene	
Boring	Mineral lard Paraffin oil 28° Bé.	Mineral lard Compound	Dry	Compound	Dry Compound	Dry	Dry	Dry	Kerosene	
Milling	Mineral lard Compound	Compound Mineral lard	Dry Comp. air	Compound Water	Compound	Dry Compound	Dry or comp. Kerosene	Mineral lard	Kerosene	Compound
Drilling	Mineral lard (Hard) Turpentine	Mineral lard Compound	Dry Comp. air	Compound Mineral lard	Compound	Dry	Compound Dry	Mineral lard	Kerosene Beeswax or tallow	Compound
Reaming	Lard oil Sperm oil	Lard oil Mineral lard	Dry Mineral lard	Lard oil Mineral lard	Compound	Dry	Dry	Mineral lard	Kerosene	
Tapping	Lard oil Cottonseed	Lard oil Cottonseed	Lard oil Compound	Lard oil Compound	Lard oil Compound	Lard oil Compound	Lard oil Lard oil and white lead	Lard oil	Lard oil Kerosene	
Tapping nuts		Mineral lard Compound		Mineral lard Compound		Mineral lard Compound				
Broaching	Neatsfoot oil Compound	Neatsfoot oil Compound	Dry	Neatsfoot oil Compound	Neatsfoot oil Compound	Dry	Neatsfoot oil Compound		Kerosene	
Gear cutting	Lard oil	Mineral lard Compound	Dry Compound		Compound		Mineral lard Compound			
Gear planing	Mineral lard	Mineral lard	Dry		Compound Mineral lard	Dry	Dry			
Gear hobbing	Lard oil Mineral lard	Mineral lard	Dry Compound		Compound	Dry	Lard oil Mineral lard			
Gear shaper	Lard oil Mineral lard	Lard oil Compound	Compound			Compound	Compound			
Auto. screw machine work	Lard oil Mineral lard	Mineral lard Paraf. and mineral lard		Mineral lard Paraffin and mineral lard		Mineral lard Paraffin oil	Mineral lard	Mineral lard	Mineral lard Compound	
Thread cutting	Lard oil Cottonseed	Mineral lard Cottonseed	Dry	Mineral lard Cottonseed	Dry Compound	Dry	Dry Mineral lard	Dry	Kerosene	Lard oil and white lead
Thread milling	Mineral lard Paraffin oil 28° Bé.	Mineral lard Paraffin oil 28° Bé.	Dry		Dry Compound	Mineral lard Compound				
Threading dies	Lard oil Sperm oil	Mineral lard Compound		Lard oil Mineral lard	Dry Compound	Mineral lard Compound				
Cold-saws	Mineral lard	Mineral lard Compound	Dry Compound	Mineral lard Compound	Compound	Dry	Compound Dry	Compound Dry		Compound
Grinding	Compound	Compound	Compound	Compound	Compound	Compound	Compound	Soda water		

Machinery

[1] Babbitt, hard rubber and fiber are machined dry with few exceptions. Lard oil or soap may be used when tapping babbitt; water when turning hard rubber, and soap compound when tapping, boring, milling, drilling and reaming; turpentine or kerosene is used when drilling and reaming glass.

at once became evident that there are no accepted standards of practice; different manufacturers use different lubricants for the same work, and as previously explained, each may obtain the same amount of service for his money, owing to variations in the life of different oils and of tools lubricated with these oils, regardless of the fact that oils used for the same purpose may be of widely different price. In Table IV information is given concerning lubricants for the different machining operations on materials commonly worked in machine shops. It will be noticed that in most cases two lubricants are named, these being given in the order in which they are most generally used. It was impracticable to tabulate all the information available concerning lubricants for different machining operations and metals, but the following paragraphs supplement the table by giving additional cutting lubricants that have been found to give good service. As in the case of Table IV, these are named in the order in which experience has shown they are most generally used. Where the use of "compound" is recommended, it means any of the emulsions made by mixing soluble oil or paste with water. Attention is called to the fact that no recommendations are made in the case of such materials as cast iron, etc., where it is good practice to conduct the machining operation dry.

Automatic Screw Machine Work—High-carbon and alloy steel: lard oil, mineral lard oil consisting of ten parts mineral lard oil and one part kerosene. Low-carbon steel: mineral lard oil, asphaltic base petroleum oil, paraffin oil and mineral lard oil in equal proportions. Wrought iron: mineral lard oil, asphaltic base petroleum oil. Brass: mineral lard oil, light paraffin oil. Bronze: mineral lard oil, asphaltic base petroleum oil. Copper: mineral lard oil. Aluminum: mineral lard oil, compound. Hard rubber: dry, compressed air. Fiber: dry. In all cases the mineral lard oil mixture may run anywhere from equal parts of mineral oil and lard oil down to 70 per cent mineral oil and 30 per cent lard oil.

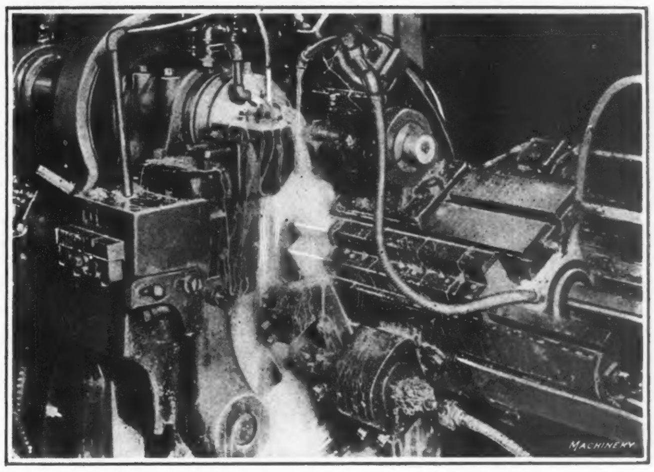


Fig. 79. Application of Lubricant to Tools on Automatic Screw Machine

Boring—High-carbon and alloy steel: mineral lard oil, lard oil, paraffin oil. Low-carbon steel: mineral lard oil, petroleum oil, compound. Brass: compound. Bronze: compound. Copper: lard oil or kerosene. Aluminum: kerosene.

Broaching—High-carbon steel: neatsfoot oil, compound. Low-carbon steel: neatsfoot oil, compound. Wrought iron: neatsfoot oil, compound. Malleable iron: neatsfoot oil, compound. Bronze: neatsfoot oil, compound.

Cutting off with Cold-saws—High-carbon and alloy steel: mineral lard oil, mixture of two parts kerosene and one part signal oil, petroleum oil. Low-carbon steel: mineral lard oil, petroleum oil, compound, mixture of two parts kerosene and one part signal oil. Wrought iron: mineral lard oil, petroleum oil, compound. Bronze: compound.

Cutting off with Hacksaw Machines—On all metals use soda-water mixture of two pounds soda to three gallons water.

TABLE V. APPROXIMATE DEGREES OF DILUTION (PARTS OF WATER PER PART OF OIL OR PASTE) FOR CUTTING COMPOUNDS ON DIFFERENT MACHINING OPERATIONS

Name of Company	Compounds and Oils	Cost per Gallon	Turning and Boring	Milling	Drilling	Cold-saws	Grinding	Threading	Gear Cutting	Gear Hobbing	Nut Tapping	Broaching
A.L.A. Mfg. & Sup. Co.	A. L. A. Compound	0.06½[1]	16	32	32	....	....	16	....	....	....	....
	A. L. A. Hydrosol	60	20	30	30	....	....	20	....	....	....	....
American Oil Corp. ...	Am. Cutting Comp.	....	16	16	16	....	16	....	....	....	....	....
	Oleosity	....	16	16	16	....	50	....	....	....	....	....
American Oil Prod. Co.	Opco-lardo	0.60	25 to 30	25 to 30	40 to 50	25 to 30	25 to 30	25 to 40	10 to 15	10 to 15	30 to 40	....
Baum's Castorine Co..	Baum's Compound	0.11[1]	20	20	30	20	20	16	16	16	20	16
Bayerson Oil Works..	Emulso	0.52	6 to 11	20 to 30	20 to 30	20 to 30	20 to 30	6 to 11	6 to 11	....	6 to 11	....
Climax Refining Co......	Climax Perfection	0.10[1]	16	16	16	12	....	8	8	8	16	8
Crescent Oil Co........	Aqualene	0.85	30	30	30	30	50	20	15	15	20	10
	Duocene	0.50	25	25	50	25	50	Straight	Straight	Straight	20	Straight
	Solucene	0.55	20	20	20	20	25	15	10	10	10	8
J. L. Fannon & Co.......	Lardoleum	0.48	16	12	16	16	20	8	12	12	8	Straight
Garnet Co..................	Triprocess	0.98	8 to 12	8 to 12	8 to 12	3 to 10	20	Straight 10	12	Straight 5	Straight 10	10
Hawkeye Oil Co.........	Faultless	0.08[1]	16	12	16	12	12	12	8	10	16	16
George A. Haws, Inc..	Marnile	....	20 to 35	10 to 25	10 to 40	10 to 35	40 to 50	5 to 10	20 to 30	20 to 30	15	18
Interstate Chemical Co.	Key brand	0.06½[1]	20	20	40	40	40	13 to 16	16 to 20	16 to 20	20	27
	Key sol	0.40	25	25	25 to 50	25 to 50	25	16	16	16	16	25
Lucent Oil Co............	Tul-lub	0.45	6 to 24	16 to 24	6 to 48	6 to 24	....	3 to 24	Straight	Straight	6 to 24	....
Magie Bros.................	Challenge	0.07¼[1]	....	....	48	....	....	....	....	....	....	....
	Rock brand	0.06[1]	10	10	....	10	....	....	10	....	....	....
Moore Oil Co...............	Buckeye	0.08[1]	25	35	25	20	30	8	25	10	10	10
	Solubo	0.50	20	30	20	18	25	7	22	9	10	8
Oil City Oil & Grease Co.	Germania Lubro	0.60	12	20	30	50	50	12	12	12	12	12
Paragon Refining Co.	Emulsol	0.60	25	25	25	15	25	10	6	15	8	10
Pennsylvania Lubricating Co.......................	Palubco	0.05[1]	20	20	20	50	50	16	20	20	16	24
	Kutwell	0.45	20	25	35	40	50	12	25	25	20	25
	Kut-o-lene	0.06[1]	24	28	28	32	50	16	24	24	20	28
B. G. Pratt Co............	Hydroil	1.00	32	60	60	20	40 to 60	20	30	45	20	....
	New Departure	0.60	32	60	60	15	40 to 60	12 to 15	30	45	12 to 15	....
Racine Tool & Mach. Co.	Peerless compound	0.11	50	50	50	50	50	50	50	50	50	....
	Peerless soluble oil	0.60	50	50	50	50	50	50	50	50	50	....
W. C. Robinson & Son Co......................	Aquasol	0.38	10 to 13	30 to 35	30 to 35	15 to 18	40 to 45	12 to 15	25 to 30	25 to 30	25 to 30	25 to 35
	Soluble cutol	0.45	12 to 16	35 to 40	35 to 40	20	40 to 50	15 to 18	30 to 40	30 to 40	25 to 40	30 to 40
	Oriole	0.08[1]	....	....	....	....	....	....	....	....	....	....
L. Sonneborn Sons, Inc.	Amalie C	....	25	25 to 34	25 to 34	50	50	25	10 to 25	10 to 25	25	....
	Amalie D	....	25	25 to 34	25 to 34	50	50	25	10 to 25	10 to 25	25	....
D. A. Stuart & Co., Inc.	Kleen-kut	....	7 to 10	15 to 25	15 to 25	15	25	15 to 25	10	10 to 15	10 to 25	....
	A	0.60	15	15	30	25	60	15	10	10	15	5
	AA	0.70	18	18	35	30	60	18	15	15	20	10
Ulco Oil Co.................	Nagle soluble oil	0.65	30 to 50	30 to 50	30 to 50	10 to 25	50 to 100	8 to 25	5 to 25	8 to 25	5 to 15	3 to 20
Union Petroleum Co...	Exanol	0.50	10 to 16[2]	25 to 50	50	50	200	10 to 16	10 to 16	....	10 to 16	....
Vortex Mfg. Co...........	Vorco soluble oil	0.51	20	20	20	20	50	30	20	20	20	....
	Alumincut	0.53	20	20	20	20	20	0	....	....	....	20
White & Bagley Co......	Eco. cutting lubricant	0.07	35	16	35	35	....	13	13	13	13	6
	Eco. grinding lubricant	0.10	....	....	....	....	32	....	....	....	....	....
White Star Refining Co.	White Star	0.45	20	17	36	36	20	7½	17	17	7½	17

Machinery

[1]Cost of paste per pound. [2]Add one quart of kerosene to each fifty gallons.

TABLE VI. COMMERCIAL OIL MIXTURES RECOMMENDED FOR VARIOUS MACHINING OPERATIONS

Name of Company	Compounds and Oils	Cost per Gallon	Turning and Boring	Milling	Drilling	Cold-saws	Grinding	Threading	Gear Cutting	Gear Hobbing	Nut Tapping	Broaching
American Oil Products Co.	Opco Lardo	$0.60	40 to 50% fuel oil 20 to 30% ker.	40 to 50% fuel oil 20 to 30% ker.	40 to 50% fuel oil 20 to 30% fuel oil	40 to 50% fuel oil 20 to 30% ker.	20% fuel oil	40 to 50% fuel oil	20% fuel oil	20% fuel oil	20 to 30% fuel oil	....
Franklin Oil & Gas Co.	Extra special cutting oil	......	50% ker.	50% ker.	50% ker.	50% ker.	....	15% ker.	15% ker.	15% ker.	15% ker.	15% ker.
	No. 650 cutting oil	......	Straight	15% ker.	15% ker.	25% ker.	....	Straight	Straight	Straight	Straight	Straight
	Perfection cutting oil	......	15% ker.	25% ker.	25% ker.	25% ker.	....	Straight	Straight	Straight	Straight	15% ker.
	No. 660 cutting oil	......	25% ker.	25% ker.	40% ker.	50% ker.	....	Straight	Straight or 15% ker.	Straight or 15% ker.	Straight	25% ker.
Penn. Lubricating Co.	Pen-o-lard[1]	0.50	50%	70%	70%	20 to 1	....	30 to 50%	20 to 40%	30%	20 to 40%	30 to 50%
G. Whitfield Richards	Near-a-lard[1]	0.50	30%	50%	50%	....	....	30%	30%	40%	50%	50%
D. A. Stuart & Co., Inc.	Dascolene	0.60	30% ker.	30% ker.	30% ker.	50% ker.	16 to 1 of soda water	Straight or 40% paraf.	Straight or 40% paraf.	Straight or 50% paraf.	30% ker.	Straight
	Dasco mineralized lard oil	0.45	20% paraf.	20% ker.	20% ker.	50% ker.	16 to 1 of soda water	Straight	Straight	Straight	50% paraf.	Straight
	Dasco gear cutting oil	0.65	....	....	....	....	....	....	Straight	Straight	....	....
	Dasco auto. cutting oil	0.50	30% paraf.	30% paraf.	30% paraf.	....	....	30% paraf.	....	....	....	....
	Dasco screw cutting oil	0.40	Straight	Straight	Straight	Straight	....	Straight	Straight	Straight	Straight	Straight
Union Petroleum Co.	Mineral lard oil	0.55	40% 28° paraf.[2] 30% fuel oil[3]	....	....	....	....	40% 28° paraf.[2] Straight[4]	40% 28° paraf.[2] 30% 28° paraf.	30% ker. 40% 28° paraf.[2]	30% ker. 40% 28° paraf.[2]	Straight 30% 28° paraf.

Machinery

[1] Dilute with kerosene, fuel oil, light gravity neutral or paraffin oil. [2] Dilute mixture with 30 per cent 300-degree burning oil. [3] For machining 3½ per cent nickel high-carbon steel. [4] For use on cast iron.

Drilling—High-carbon and alloy steel: mineral lard oil, lard oil. Low-carbon steel: mineral lard oil, petroleum oil, compound. Very hard steel: turpentine or mixture of turpentine and spirits of camphor, kerosene. Cast iron: compressed air. Wrought iron: mineral lard oil, petroleum oil, compound. Malleable iron: compound, petroleum oil. Brass: compound. Bronze: compound. Copper: lard oil, mineral lard oil, kerosene. Aluminum: kerosene, beeswax or tallow (rubbed on rotating drill after cutting two or three holes. Monel metal: compound. Glass: turpentine, turpentine and spirits of camphor, kerosene.

Forming—High-carbon and alloy steel: mineral lard oil, lard oil, paraffin oil, mixture of two parts kerosene and one part signal oil. Low-carbon steel: mineral lard oil, petroleum oil, compound, mixture of two parts kerosene and one part signal oil. Wrought iron: petroleum oil, compound. Brass: compound. Copper: lard oil or kerosene. Aluminum: kerosene.

Gear Cutting—High-carbon and alloy steel: lard oil, mineral lard oil. Low-carbon steel: mineral lard oil, petroleum oil, compound. Bronze: lard oil, mineral lard oil, compound.

Gear Hobbing—High-carbon and alloy steel: lard oil, mineral lard oil. Low-carbon steel: mineral lard oil. Cast iron: compound. Brass: compound. Bronze: mineral lard oil, compound.

Gear Planing—High-carbon and alloy steel: mineral lard oil. Low-carbon steel: mineral lard oil. Bronze: mineral lard oil.

Gear Shaping—High-carbon and alloy steel: lard oil, mineral lard oil, turpentine, kerosene. Low-carbon steel: mineral lard oil, compound, turpentine, kerosene (on steel where trouble is experienced from tearing the metal, add a small amount of powdered sulphur to the lard oil or mineral lard oil). Cast iron: compound. Brass and bronze: compound.

Grinding—High-carbon and alloy steel: compound. Low-carbon steel: compound. Cast iron: compound. Wrought iron: compound. Brass: compound. Bronze: compound.

Milling—High-carbon and alloy steel: mineral lard oil, compound, petroleum oil, paraffin oil, lard oil. Low-carbon steel: compound, mineral lard oil, petroleum oil. Cast iron: compressed air. Wrought iron: mineral lard oil, compound, petroleum oil, soda water. Brass: compound. Bronze: compound, kerosene. Copper: mineral lard oil, lard oil, kerosene. Aluminum: kerosene.

Reaming—High-carbon and alloy steel: lard oil, mineral lard oil, sperm oil, mixture of lard oil and white lead of about consistency of glue. Low-carbon steel: lard oil, mineral lard oil, compound, lard oil and white lead. Wrought iron: lard oil, mineral lard oil. Brass: compound. Copper: mineral lard oil, lard oil, kerosene. Aluminum: lard oil, kerosene.

Tapping—High-carbon and alloy steel: lard oil, mineral lard oil, mixture of 90 per cent tallow and 10 per cent graphite, cottonseed oil. Low-carbon steel: lard oil, mineral lard oil, tallow and graphite, lard oil and white lead mixed to consistency of glue, cottonseed oil. Cast iron: lard oil, compound, white lead. Wrought iron: lard oil, compound. Malleable iron: lard oil, compound. Brass: lard oil, lard oil and white lead mixed to consistency of glue. Copper: lard oil. Aluminum: lard oil, kerosene, beeswax or tallow (rubbed on rotating tap after each operation). Babbitt: lard oil, soap (packed into hole before tapping). Nuts: mineral lard oil compound.

Thread Cutting—High-carbon and alloy steel: lard oil, mineral lard oil, cottonseed oil, grapeseed oil. Low-carbon steel: mineral lard oil, mixture of mineral lard oil and 25 to 50 per cent kerosene, turpentine and white lead, lard oil, cottonseed oil, grapeseed oil. Very hard steel: turpentine. Wrought iron: mineral lard oil, compound. Brass: compound. Bronze: mineral lard oil. Copper: mineral lard oil. Aluminum: kerosene. Monel metal: mixture of lard oil and white lead reduced to consistency of glue.

Thread Milling—High-carbon and alloy steel: mineral lard oil, paraffin oil. Low-carbon steel: mineral lard oil, paraffin oil of 28 degrees Bé. gravity.

Threading with Dies—High-carbon and alloy steel: lard oil, sperm oil. Low-carbon steel: lard oil, mineral lard oil, compound. Wrought iron: lard oil, mineral lard oil. Brass: mineral lard oil, compound. Copper: lard oil, mineral lard oil.

Turning—High-carbon and alloy steel: mineral lard oil, lard oil, compound, paraffin oil of 28 degrees Bé. gravity, signal oil. Low-carbon steel: mineral lard oil, signal oil, petroleum oil, compound. Wrought iron: petroleum oil, compound. Brass: compound. Bronze: compound. Copper: lard oil or kerosene. Aluminum: kerosene. Monel metal: compound. Hard rubber: cold water.

Importance of Complete Stability of Cutting Emulsions

When cutting emulsions are made by mixing paste or soluble oil with water it is important for the oil or paste to be uniformly mixed in the water and for the emulsion to be stable at all temperatures under which it is likely to be used. When this is not the case, there is danger of certain constituents of the oil settling out in layers, resulting in lack of uniformity of the emulsion, which will prevent it from having the maximum lubricating effect, and may cause rusting of machines and product. The user of cutting compounds will do well to place in tall glass bottlec test samples mixed with water in the proportions recommended for the class of work on which the emulsion is to be applied and observe whether there is any tendency for the constituents to settle out. Any compounds which show this tendency should not be used.

Mixing Cutting Oils and Emulsions

In order to secure the best results with mixtures of oil or cutting emulsions which the consumer mixes in his own shop, great care should be taken to follow the instructions given by the firm from which oils are purchased, as even slight deviations from the recommended practice will often seriously reduce the efficiency in cooling or lubricating. It is good practice to standardize cutting lubricants as far as possible, and in every case a competent person should have charge of their handling and mixing. Satisfactory results cannot be expected

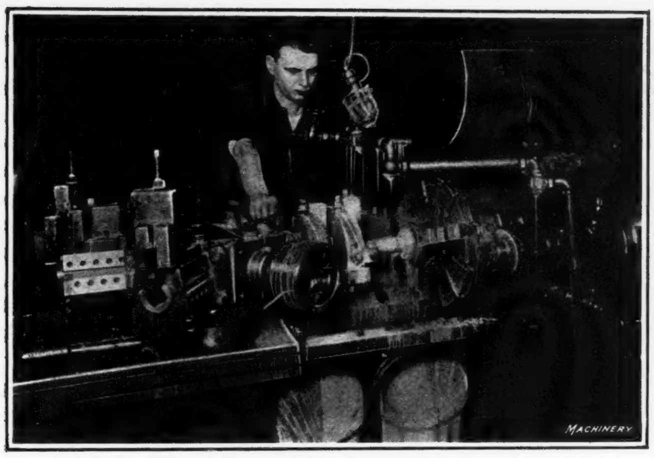


Fig. 80. Arrangement of Piping for delivering Oil to Tools on Turret Lathe

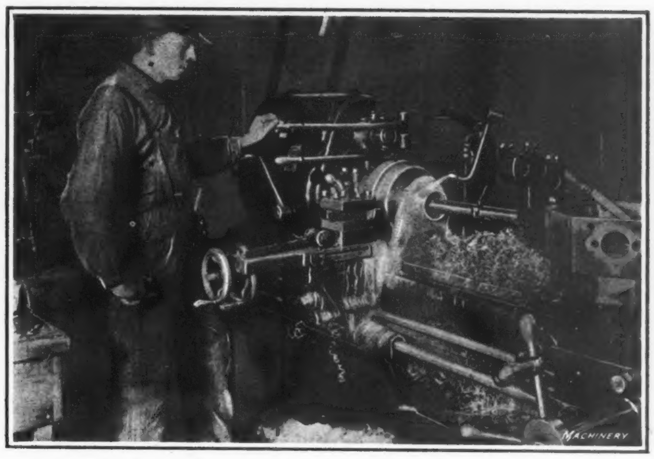


Fig. 81. Jointed Delivery Pipe which makes it Possible to direct Fluid exactly to Desired Position

where the practice is followed of allowing each operator to make up his own mixture, as this tends to destroy uniformity and there will be many cases in which unsuitable mixtures will be used. It is a good plan to have a printed schedule of lubricating practice placed in the hands of each shop superintendent and department foreman, showing the kind of lubricants to use for all classes of work. Such schedules will show the formulas used by the man who has charge of making up oil mixtures, and in cases of trouble they will assist in determining whether the proper lubricant has been supplied for handling a given job. This practice will also be the means of reducing the consumption of lubricants and of obtaining lubricants that will give satisfactory results.

In mixing cutting emulsions and oils—particularly in cases where there is a lot of mixing to be done—equipment should be provided that will enable this work to be conducted with the least possible delay, and that will also guard against the loss of material that is bound to occur when buckets and other slipshod methods are used for handling various metals. Fig. 77, which appears in the third installment of this article, published in the March number, shows an excellent arrangement of equipment for conducting mixing operations. This consits of a barrel located on the floor above the main storage tank from which lubricant is pumped to the gravity tank that supplies the various machines in the factory. Leading into this barrel there are a steam pipe and a water pipe, either of which may be opened to provide for boiling the ingredients of cutting emulsions or diluting them as required. Below the barrel is a valve connecting with a pipe leading to the storage tank; after the mixture has been made up this valve is opened to allow the lubricant to run into the tank.

Formulas for Homemade Cutting Emulsions

The following are formulas for cutting emulsions which well-known manufacturers have found to give very satisfactory results. It will be noted that some of these are recommended for general application on those classes of work on which compounds give satisfactory results, while in certain other cases compounds are especially recommended for specific machining operations. In this connection, the reader's attention is called to the formulas for making emulsions that are given out by many oil manufacturers. Naturally these have especial reference to trademarked oils sold by these firms, and as they call for the use of these special ingredients, no mention is made of them in the following section of this article.

Soda-water mixtures are still used to a considerable extent, but while they possess an advantage over plain water in that there is no tendency to rust the tools or work, soda water has no greater lubricating effect than pure water. The following gives the formula for a soda-water mixture containing lard oil, which has a lubricating effect in addition to the usual properties of pure soda water: Mix ¼ pound sal soda, ½ pint lard oil and ½ pint soft soap with enough water to make ten quarts. This mixture is boiled for one-half hour and is ready for use after cooling to normal temperature. This will give very satisfactory results for all classes of work on which cutting compounds can be used, except for drilling, and in this case the stock soda-water solution should be thinned down considerably to prevent foaming.

For general use in drilling, milling and other operations for which a cutting compound may be used, the following formula produces a coolant that will be found to give very satisfactory results: Take two galvanized iron buckets and fill one two-thirds full with No. 1 lard oil and the other two-thirds full with No. 1 screw cutting oil. To one pail add a pint measure of Proctor & Gamble's white soap chips and to the other pail add one-half pound of powdered soda. The contents of these two pails are then poured into a wooden barrel and thoroughly boiled with live steam which results in dissolving the soap and soda and thoroughly mixing it with the oil. After this has been done, the barrel is filled with cold water and thoroughly stirred to secure a uniform mixture, after which the contents are run into the storage tank of the central distributing station, from which pumps deliver it to circulating pipes leading to the machines in the factory.

For drilling and milling operations, the following formula gives a good cutting compound: Dissolve 2½ pounds soda ash in water and mix with 2 or 3 gallons lubricating oil. These constituents are thoroughly stirred to secure a uniform mixture and are then added to 40 gallons water.

For all milling, turning and drilling operations, the following formula produces a good compound: Dissolve 1¾ pound sal soda in 10 gallons water and boil the solution with a steam jet, then add 1 gallon lard oil.

For reaming and tapping holes for staybolts, one of the largest locomotive shops in the country uses a compound made up according to the following formula: Mix 18 gallons good-grade lard oil, 60 pounds tallow and 100 pounds white lead.

To make a grinding compound, the following formula is highly recommended: Dissolve 75 pounds soft soap and 30 pounds sal soda in 15 gallons boiling water. Keep the mixture boiling and stir in 10 gallons lard oil. To this mixture add 1 ounce creosote oil as a disinfectant. When cool, mix 1 gallon of this stock solution with 3 gallons water to make the compound delivered to the wheel and work.

To make a lubricant for gear-cutting with rotary cutters or hobs, the following formula produces an emulsion that gives excellent results: Stir together 3½ gallons mineral lard oil and 2¾ pounds sal soda, and when thoroughly mixed add to one barrel of soft water. This compound does not thicken or leave a gummy residue.

Effect of Oil or Cutting Compound on Power Required to Drive Machine Tools

There is considerable diversity of opinion concerning the effect of oil or cutting compound on the amount of power required to drive the machine. Some investigators in this field have been unable to secure results that show any reduction of power consumption through the use of oil or cutting compound as compared with operating tools dry. Others have found a marked difference in favor of the lubricated cutting tools, and it seems reasonable to assume in cases where no improvement has been found that the tool was probably work-

ing on those classes of metal where fairly satisfactory results might be obtained without the use of a lubricant. The following gives the experience of one or two investigators who have found cutting lubricant to be a valuable factor in reducing the amount of power required by the machine.

At the plant of the Bullard Machine Tool Co., Bridgeport, Conn., a machine was working on a steel casting which had about ¾ inch left on the diameter for machining. The surface to be finished was about 16 inches wide, and two large streams of cutting compound were delivered to the tools which were taking two cuts, one at the top and one at the side. The cutting compound was delivered at the rate of about thirty-six quarts per minute directly to the tools, but even under these conditions the chips turned blue when they came out from the cutting compound. With a view to determining the effect of the compound upon the machine's power factor, the experiment was tried of shutting off the flow while the machine was in operation under the conditions mentioned. When this was done the machine made one-half revolution and then the belt went off. It was expected that the tools were either broken or burned, but an investigation showed that they were still in perfectly good condition because the machine had not run far enough to cause damage in this way.

After putting on the belt, the machine was started and continued to run satisfactorily until the flow of lubricant was again shut off; then the machine went less than one-half revolution before the belt was again thrown off. This experiment was tried a sufficient number of times to show conclusively that there was a direct relation between the power factor and the lubricant. With the view of obtaining definite information on this subject, the machine was provided with a motor attached to a recording watt meter, and with this equipment it was found that on heavy cutting there was a difference of as much as 43 per cent in the power required to machine a piece with and without the application of cutting lubricant to the tools. With machines working on smaller work and taking lighter cuts, less difference was found.

Further experiments conducted along the same lines showed that pieces machined without the use of cutting lubricant became so badly heated that they were difficult to handle, and the expansion and subsequent contraction had seriously affected the accuracy of the dimensions. For instance, a hole 15 inches in diameter when a piece was cold became 15.009 inches when a light facing cut was taken across the top of the casting, so that measurements made while the piece was hot had to be corrected for expansion, which was often a difficult matter. The elimination of such inaccuracies and the saving of power are of sufficient advantage to warrant the use of cutting lubricants in turning such materials as cast iron, where the use of lubricant is not an absolute necessity.

Experiments conducted in England by Dempster Smith showed that where lubricants were used in drilling with twist drills, using a feed of 0.040 inch per revolution, the torque was 72 per cent, and with a feed of 0.030 inch per revolution the torque was increased to 92 per cent of the value obtained when operating the drill dry. When machining soft, medium and hard steel, the respective thrusts were 26, 37 and 12 per cent less when a lubricant was used than when the drill was operated dry, but no marked difference was found for different rates of feed, as in the case of the torque. Experiments conducted with boring-bars and trepanning tools showed the following relation of power consumption for different conditions of operation: Tool operated dry, relative power consumption, 1; pure water delivered to tool, relative power consumption, 0.91; soap and water delivered to tool, relative power consumption, 0.94; emulsion of oil and water delivered to tool, relative power consumption, 0.87.

Another investigator found that thorough lubrication of twist drills reduces end thrust by 35 per cent and torque by 20 per cent of the values secured when operating the tool dry, thus effecting a large saving of power as well as increasing the working efficiency and duration of sharp cutting edges for the drill.

On March 12, 1912, Harry E. Harris, who at that time was engineer of tests for Wells Bros. Co., Greenfield, Mass., read a paper before the American Society of Mechanical Engineers in New York City entitled "Data on Taps and Tapping," in which was given the following information on the lubrication of taps and the effect of cutting lubricant upon the power consumed by the machine. Table VII, which was presented in connection with that paper, shows the effect of varying the tap drill sizes and using different lubricants for performing the tapping operation. The data presented in this table show that the power required to break a properly made ½-inch, 13-thread per inch U. S. standard tap is approximately 1000 inch-pounds. For comparative purposes this breaking strain is taken as 100, and the lesser strains required for tapping holes under different conditions are expressed as percentages of this breaking strain. Multiplying the percentage given in the table by 10 gives the actual average power in inch-pounds. The test pieces were common hexagon cold-punched nuts, accurately reamed to respective sizes, and the taps were regular ½-inch U. S. standard taps. This series of tests shows the following points:

(1) Up to a certain point, lubricants have the same effect on the driving power required as would be exerted by the presence of more or less metal to be removed. For instance, a tap in a ½-inch nut with a 0.425-inch tap hole, using machine oil instead of sperm oil, would have practically the same effect on the power required as reducing the diameter of the tap hole 25 per cent of the total depth of the thread. Referring to Table VII, it will be seen that the power is approximately doubled in both cases; 16.5 per cent to 34.2 per cent in changing from sperm oil to machine oil for a tap hole 0.425 inch in diameter; and 16.5 for sperm oil with a 0.425-inch tap hole changes to 35.5 for the same cutting lubricant with a 0.400-inch tap hole. (2) Animal lard oil, sperm oil, and graphite and tallow mixture are the best lubricants of those tested. (3) A good soap compound is better than mineral lard oil for tapping. (4) Machine oil is a detriment instead of a help, as taps are cut better dry than with this lubricant. (5) Breakage of taps can be greatly reduced by the use of a proper lubricant, and taps should never be run dry when machining steel.

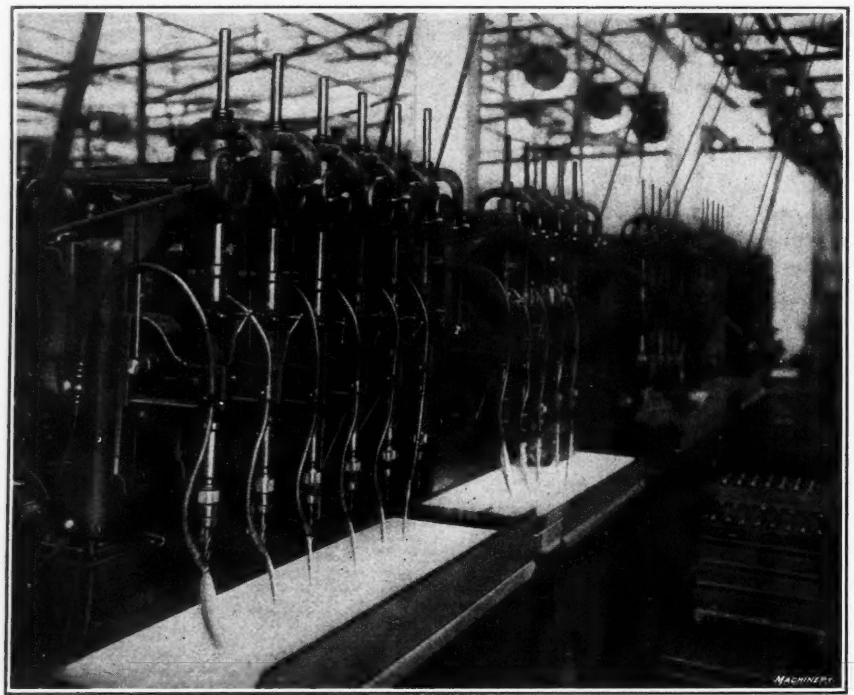


Fig. 82. Multiple-spindle Drill Presses with Flexible Tubes for delivering Cutting Compound to Tools

Fire Hazard in Use of Cutting Oil

The use of water for cutting purposes, while quite desirable from a fire standpoint, was soon found to produce inferior results as compared to oil, owing to the fact that for certain classes of work a greater measure of lubrication was desirable, and the water caused trouble by rusting the machines. The use of oil has therefore increased rapidly in the last fifteen years, owing to the great development of high-speed tools, until at present the modern machine shop frequently contains large quantities of cutting oil pretty well exposed and distributed throughout the shop. This oil is used over and over again in circulating systems which may involve an individual pan or reservoir for the oil and a pump for each machine or a system of pipes through which the oil is carried back to a main storage tank, and then forced by one large pump back into the system, feeding several machines.

The fire hazard which these large quantities of oil may present was strongly emphasized during the past year, when a large machine shop was completely destroyed by fire. The building was not equipped with sprinklers and the construction was not of the best, but the rapidity with which the fire spread brought up the question as to whether the large quantities of cutting oil, which in that case contained a considerable proportion of kerosene, had not been an important factor in the rapid spread of the fire.

It was therefore decided to have the Inspection Department of the Associated Factory Mutual Fire Insurance Cos., 31 Milk St., Boston, Mass., conduct an investigation of the matter of cutting oil hazard, and the following information is taken from its report. This investigation has been conducted along three lines; first, a study by means of reports prepared by the regular inspectors of conditions in risks, covering the amount and character of the oils used, the general conditions with respect to oil-soaking of the floors, use of sawdust, etc.; second, a laboratory investigation covering flash and fire points, spontaneous combustion tests and viscosity measurements of samples obtained from risks, and also of mixtures prepared in the laboratory; third, a series of fire tests to determine the hazard of oil-soaked wood, the readiness of ignition and spread of fires in oil-soaked sawdust and steel chips, the ignition of oil in pans, methods of extinguishing oil fires, etc.

The amount of oil used varies considerably with the kind of machine, some using not more than four or five gallons, while a few of the large automatics use thirty to fifty gallons. Ten gallons per machine, however, may be considered a fair average.

The majority of factories use the individual pumping system, in which a pump is provided for each machine. A few, however, have large systems in which one pump may supply fifty or more machines. In some mills both systems are used. Paradoxical as it may seem at first, it is believed that the multiple feed system, where it can be properly arranged, is the safer. With this system it is possible to reduce materially the amount of oil in important buildings, as the storage tank and pump can be located outside. This arrangement, of course, requires more or less piping carrying oil, but this is believed to be less of a hazard than the presence of a large number of open oil pans.

Splashing and Oil-soaking of Floors

From a study of the conditions in several plants, it became evident that there is a wide difference in the amount of oil which gets on the floor. Some shops have made a special study of guards for catching oil and preventing it from reaching the floor, while others have apparently paid no attention whatever to this matter. One shop did a piece of investigation work that showed unusual interest in solving this problem. A machine was set up in an open space where it could be easily observed, and blotting paper was placed all around it on the floor. The foremen of the different departments were then assembled, and the machine was started. Each man was instructed to watch a certain part of the floor, and whenever a drop of oil struck, it was traced back to the point from which it came, and a guard was constructed to catch this oil. By this means the machine was completely guarded, so that it threw no oil whatever on the floor. This process was repeated with the different types of machines in the plant, resulting in a clean shop with practically no oil on the floor, greater economy and much safer conditions as respects fire hazard.

The manufacturers of machine tools make guards to be used with their machines, but these are sold separately and are ordered in only a few cases by the purchasers of the machines. It is undoubtedly true that it is impossible to guard some machines completely without interfering with the operation, but this is not true in the majority of cases, and there is certainly room for a great deal of improvement over present conditions in many risks.

A frequent offender in the splashing of oil on the floor is the pump, where the individual feed is used. The pumps are sometimes placed at one side of the oil pan of the machine, and as the stuffing-boxes frequently leak, they throw large

TABLE VII. EFFECTS OF VARIOUS LUBRICANTS AND DIFFERENT TAP DRILL DIAMETERS ON CUTTING ACTION AND BREAKING OF TAPS[1]

Lubricant	Animal Lard Oil	Sperm Oil	Graphite, 10 Per Cent; Tallow, 90 Per Cent	Cataract Soap Compound	Mineral Lard Oil	Tapping Dry	Machine Oil
0.425 Inch Diameter of Tap Hole. 75 Per Cent Thread							
Per cent of breaking strain	15.9	16.5	16.9	18.9	19.9	29.9	34.2
Breakages in tests	None	None	None	None	None	14 per cent	15 per cent
Quality of thread cut	Smooth	Smooth	Smooth	Smooth	Smooth	Rough	Torn
0.410 Inch Diameter of Tap Hole. 90 Per Cent Thread							
Per cent of breaking strain	......	23	......	25.1	36.5	60.2	68.5
Breakages in tests	......	None	......	None	None	50 per cent	71.5 per cent
Quality of thread cut	......	Smooth	......	Smooth	Smooth	Rough	Torn badly
0.400 Inch Diameter of Tap Hole. 100 Per Cent Thread							
Per cent of breaking strain	......	35.5	......	41	57.5	71.8	100
Breakages in tests	......	None	......	None	None	66 per cent	100 per cent
Quality of thread cut	......	Smooth, but with tops torn	......	Slightly rough, tops torn	Smooth, but with tops torn	Torn and partly stripped	Torn and wedged, so as to prevent tap cutting through

Machinery

[1] By multiplying the above percentages by 10, the actual average power required in inch-pounds may be obtained.

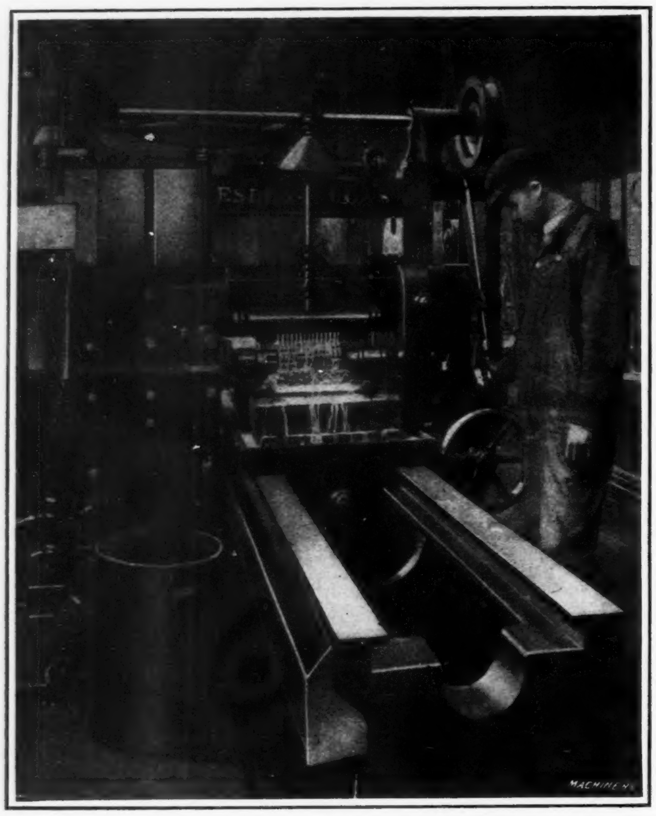


Fig. 83. Means of distributing Lubricant on Espen-Lucas Planer Type Milling Machine

quantities of oil on the floor. The pump should always be placed over the pan of the machine, and properly guarded to prevent splashing. Another frequent source of trouble is the carelessness of the workmen in handling finished pieces dripping with oil.

Probably little can be done in the way of improvement that would require much cooperation on the part of the workmen, but it is possible to improve conditions, at least in some plants, with respect to the receptacles in which the finished pieces are placed, both as regards their character and location, so as to reduce the amount of dripping to a minimum. The receptacle should be oil-tight, and should be placed as close to the machine as practicable. A sheet-iron drain or trough should also be provided between the machine and the box, so that the finished pieces would normally be conveyed over this drain from the machine to the box. These precautions are only necessary in cases where the finished work comes in contact with large quantities of oil, and has no opportunity to drain in the machine before being removed.

Use of Kerosene in Cutting Oils

The practice of adding kerosene to cutting oils, which has developed in the last few years, has been resorted to for one or more of the following reasons: first, to obtain a cutting oil which will cool the work and tool rapidly, and carry the chips away quickly, but which will still possess considerable lubricating value; second, to cheapen the cost of the cutting medium; third, to prevent gumming or thickening of the cutting oil.

It is clear that the addition of kerosene at 10 to 12 cents a gallon results in a material reduction in the cost per gallon of the cutting oil. The actual reduction in price, however, is less than would appear at first thought, as kerosene evaporates appreciably at room temperatures, and it is generally necessary to add more kerosene from time to time, while with the straight cutting oils, or cutting oils thinned with light mineral oils, this evaporation is practically negligible. The amount of kerosene added varies widely, ranging from 3 to 75 per cent.

In a few special operations, such as cutting aluminum, there appears to be a firmly fixed idea on the part of some manufacturers that nothing but straight kerosene can be used. There is no doubt but that the cutting of aluminum presents difficulties not found with steel, but one large manufacturer of machine tools has found it possible to use an emulsion for cutting aluminum with entirely satisfactory results.

From a careful investigation of the matter, both by means of laboratory tests and a study of conditions in different risks, the conclusion has been reached that the use of kerosene is not necessary in any case for cutting metal with the possible exception of aluminum. The kerosene has but slight lubricating value, and acts merely as a diluent to thin down the oil. This reduction in viscosity is undoubtedly necessary for some purposes, but can be effected by using light mineral oils of high flash point. Thus a shop, which has been using 25 per cent kerosene and 75 per cent lard oil, can prepare a satisfactory substitute by mixing about 40 per cent extra light spindle or transil oil with 60 per cent lard or mineral lard oil. This mixture will have a much higher flash point than that containing kerosene, and will have approximately the same viscosity and lubricating efficiency.

In extreme cases where it is absolutely necessary to have a very thin oil the kerosene may be replaced with 300-degree fire test oil. By using this product it is possible to obtain mixtures with practically as low viscosities as the kerosene mixtures having up to 50 per cent kerosene, but which have materially higher flash and fire points. It is believed, however, that it is necessary to resort to 300-degree oil only in a few cases.

In cutting aluminum some manufacturers have claimed that straight kerosene or a mixture containing a large proportion of kerosene is necessary. On the other hand, one large manufacturer of machine tools and measuring instruments has used an emulsion for cutting aluminum with entirely satisfactory results. Even though emulsions do not prove generally satisfactory for this purpose, there is little doubt but that the 300-degree fire test oil could be used in place of kerosene.

Tests were made on oil-soaked mixtures of sawdust and bicarbonate of soda containing varying proportions in order to determine the effect of the bicarbonate of soda on the combustibility of the sawdust and oil. The following mixtures were prepared, the proportions being by weight.

No.	Sawdust, Parts	Bicarbonate of Soda, Parts	Lard Oil, Parts
1	100	20	100
2	100	100	100
3	100	100	200
4	100	200	200

In sample No. 1 the bicarbonate of soda produced no visible effect on the combustibility of the mixture. In No. 2 the combustibility of the mixture was considerably retarded, but the amount of oil in this combination was considerably less than is generally found in sawdust before it is considered sufficiently saturated to warrant removal. No. 3, where the quantity of oil was doubled, and which still contained less than is frequently found in oil-soaked sawdust in mills, burned freely; the same was true of No. 4. It is evident from these tests that no amount of bicarbonate of soda, which could be used at a reasonable cost, would have any important effect on the combustibility of oil-soaked sawdust.

Conclusions

The development of high-speed tools has resulted in conditions which require the application of a cooling and lubricating medium, on the tool and work. Water and soda solutions were at first used for this purpose, but these do not furnish sufficient lubrication, and are somewhat objectionable on account of rusting the machines. Oil has therefore largely replaced water for this purpose, and its use has produced much better results from a manufacturing standpoint, making a considerable increase in the speed of the cutting tools possible. In the modern machine shop large quantities of oil, sometimes containing a high percentage of kerosene, are used in open pans as a part of circulating systems in which the oil is applied continuously to the work.

The character of the oils in use varies widely in different plants, but mineral lard oils, which are simply mixtures of lard oil and mineral oil, sometimes with other animal oils or

fats, are most commonly used. Kerosene mixed with the cutting oil has been used considerably in the last few years. In the majority of cases the chief reason for the use of the kerosene is to cheapen the cutting oil.

Type of System

The multiple feed system for supplying cutting oil to machines when properly arranged is preferable to the individual feed. With the multiple feed it is possible to locate the main storage tank outside of important buildings and therefore greatly reduce the amount of oil inside the buildings. This advantage, it is believed, more than offsets the objection to the introduction of oil-filled pipes in buildings.

Prevention of Oil Splashing

A great deal of improvement is possible in the matter of preventing oil from getting on the floor by the provision of proper oil guards. In some classes of automatic machines it is not possible to keep all the splash from reaching the floor, but in many cases this can be done, and in all cases the greater part of the splash can be caught. Oil-tight receptacles for the finished pieces should be provided, and these should be located as near the machine as practicable. Drains or troughs should also be arranged to catch the drip when the pieces are being conveyed from the machine to the box. The pumps on individual feed systems should be given attention by locating them over the oil pans, and keeping the stuffing-boxes in good condition, or providing adequate guards.

Starting of Fires

The hazard resulting from the use of large quantities of cutting oils depends to a considerable extent on the character of the oil and the condition of the floor. If a straight cutting oil is used, a fire cannot be readily started with a match or a small quantity of burning waste. Where straight cutting oil has leaked through from the floor above onto the ceiling, a fire can be started from a comparatively small source, whereas without oil no fire would result from the same cause. Fires could not be started from a match or small quantity of oily waste on floors, even where the floors were covered with as much as 50 per cent of kerosene mixed with cutting oil. In ceiling tests the oily wood ignited much more easily when kerosene was used than when it was absent, the ease of ignition being proportional to the percentage of kerosene present.

Spread of Fires

The tests showed clearly with what difficulty a small fire spreads in a horizontal direction on the top of a floor, even though the wood is oil-soaked with a mixture containing a considerable proportion of kerosene. This is purely a result of unfavorable draft conditions. The draft from such a fire is inward and upward so that the heat does not reach the wood or oil to raise it to the flash point. If, however, as the result of the presence of other readily combustible material a fire of any size is started, the presence of oil-soaked floors is undoubtedly an important factor in increasing the rate of spread and producing a hot fire. Where the oil-soaked wood is in a vertical partition, a fire does not develop very rapidly from a small source unless there is an open space under the partition to furnish a good draft. The effect of the kerosene on the partition, however, is very definite and marked, the height of the flames being dependent on the percentage of kerosene used. Fires on the under side of a ceiling spread without difficulty. This is due to the fact that the heat from the fire comes in contact with the wood immediately adjacent to the flame and heats it up to the flash point. Here again the spread of the fire is in proportion to the percentage of kerosene.

Fire in Open Pans

In open pans where straight cutting oils of a high flash point were used, the oil could not be ignited from a fire of small size such as fifty grams (approximately two ounces) of cotton waste. Where kerosene was used, however, a fire could be started with the same quantity of waste and spread rapidly. The ease of ignition of the kerosene-cutting-oil mixture depended on the percentage of kerosene.

Fire in Oily Steel Chips

The presence of steel chips on the floor or in pans aids materially in igniting the oil and spreading the fire. In pans containing steel chips and a mixture with a large percentage of kerosene, it was possible to ignite the oil with a match, whereas with smaller percentages of kerosene this could not be done.

Fire in Oil-soaked Sawdust

The use of sawdust on floors for absorbing cutting oils greatly increases the fire hazard. Where a straight cutting oil is used, a fire can be started in the oil-soaked sawdust with a match, although it does not spread rapidly. If the oil contains kerosene, however, fires can be easily started by means of a match and spread very rapidly, particularly where a large percentage of kerosene is present. When the cutting oil contains over 60 per cent of lard oil, there is a possibility of spontaneous ignition of the sawdust under favorable conditions. The use of bicarbonate of soda mixed with sawdust in any quantity, which would not be prohibitive in cost, does not materially affect the combustibility of the oil-soaked sawdust.

Extinguishers for Cutting-oil Fires

For extinguishing cutting-oil fires in pans, sawdust and bicarbonate of soda was found as efficient as any other material. In cases where large pans or several pans were involved, the sawdust and bicarbonate of soda could not, of course, be used, but such fires would have then passed outside the field of hand apparatus.

Use of Emulsions

The use of emulsions in place of cutting oils could undoubtedly be greatly extended in many plants by adopting emulsions especially compounded according to the character of the work in hand. The increased use of emulsions would result in a material reduction in the fire hazard and in the cost of lubrication.

Elimination of Kerosene

The use of kerosene cutting oils does not appear to be necessary under any conditions with one possible exception.

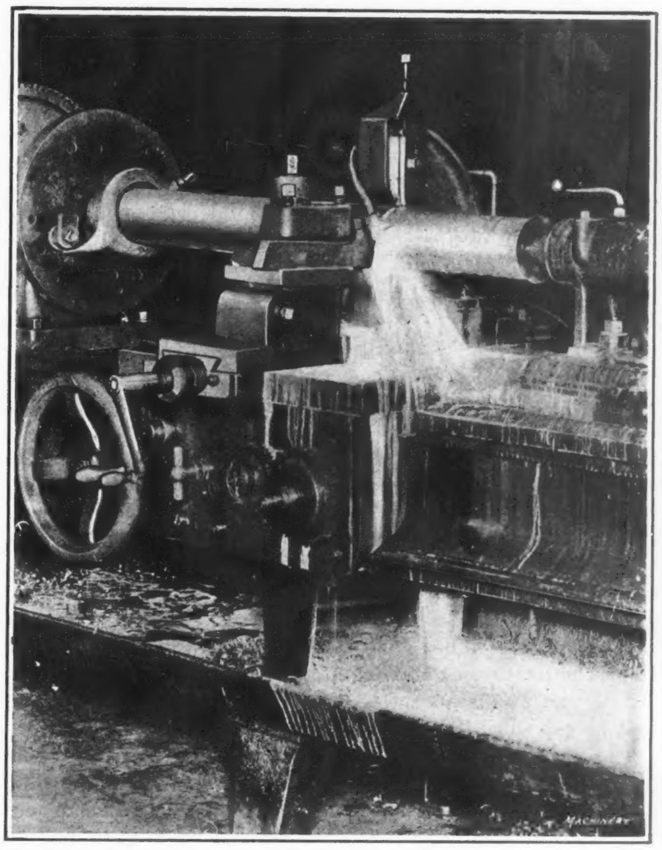


Fig. 84. Provision for delivering Copious Flow of Compound to insure Adequate Cooling of Tools and Work

This exception is in the cutting of aluminum, but even here the matter is open to question. Two or three manufacturers claim that kerosene is necessary for this purpose, but one large manufacturer of machine tools and measuring instruments uses an emulsion with entirely satisfactory results. In any event, it seems probable that even though the emulsion does not suit all requirements in cutting aluminum, 300-degree fire test oil can be generally employed in place of kerosene.

Kerosene possesses but slight lubricating properties, and its chief function is as a diluent to reduce the viscosity of the cutting oil. This object can be attained by using the proper amount of light spindle oil, or in extreme cases by adding 300-degree fire test oil. In no cases, it is believed, should oil for general cutting purposes have a fire point of less than 300 degrees F., and in the great majority of cases it can be higher. That the use of kerosene can be eliminated is shown by the fact that since this investigation was started, a number of shops have, without interfering with the efficiency of their plants, given up the use of kerosene.

* * *

COOPERATION IN SAFETY WORK

Two great safety organizations—the American Museum of Safety and the National Safety Council—have been drawn into close affiliation by the appointment of Arthur H. Young as director of the American Museum of Safety. Mr. Young is a member of the National Safety Council, and for several years was in charge of the safety work of the Illinois Steel Co. in South Chicago.

It is fitting that these two safety organizations should work in close cooperation. The one visualizes what has been accomplished by safety engineers in the matter of protecting belts, shafting, pulleys, presses, gears and other dangerous features of machinery, in promoting safety of travel and health of industrial workers by sanitary measures and appliances. The other organization deals more with the administration and promotion of safety work through the instruction of superintendents, foremen and workers in manufacturing plants. The National Safety Council has in a few years made a marked reduction in the number of accidents in the plants represented in its branch councils. These plants have shown conclusively that safety work is economic—it pays well.

The work of the two societies has defined to some extent the field of the safety engineer, a comparatively new profession likely to attract many technically educated young men as the possibilities of the work are better realized. It is difficult to estimate accurately the savings that have already resulted from safety work or to predict the savings that will be made as it is developed and as those responsible for production become familiar with its fundamental principles and the beneficent effect of human conservation.

* * *

APARTMENTS FOR WORKING MEN

Factory owners and executives in Cincinnati are particularly interested in two model tenements that have just been completed on the west side of Logan St., midway between Findlay and Elder Sts. They see in them the possible solution of housing economically industrial workers in large cities in an entirely sanitary and wholesome manner. Col. William Cooper Proctor, the man financially interested in this improvement, plans to add five more units if the present ones prove successful. The land for these has already been purchased. These seven units when completed will represent an investment of approximately half a million dollars. It is understood that while Col. Proctor has gone into the proposition more or less from a philanthropic standpoint, he plans to demonstrate that it is by no means an act of charity. In fact, he is confident that he can show it is a paying investment.

The average rental to be charged will be probably about $1.10 per room per week; this will include heat from a modern vapor system. The apartments vary in size from one to four rooms. The location is close to several crowded industrial centers and within fifteen to twenty minutes walk of the heart of the city. This location in such a crowded district, while particularly handy for the workers, necessitates as much economy as possible in the use of space. Five-story buildings were decided upon. Each of the present units contains fifty-three apartments. Besides the modern heating system in each apartment, there is a gas stove and other necessary conveniences. Screens are supplied for all windows. The children throughout each tenement have the advantage of a well-equipped playground and nursery on the roof.

A notable feature of the project, and one of prime importance, is the thoroughly fireproof construction used. The walls are of brick, and the structural columns and beams and the floors are of reinforced concrete. The partitions between the rooms are fireproof, and the doors are metal. In addition to this, the stairways serve the double purpose of stairway and fire escape, for while they are protected from the weather, they are not entirely enclosed.

The use of reinforced concrete construction for this type of building is a new departure, but it has proved entirely successful, not only from the point of the economical use of space for columns and beams, but from the point of economy, the reinforced concrete construction being considerably cheaper than structural steel columns and beams with hollow tile and concrete joist floors. William Emerson, of New York City, who has made a study of tenement construction, drew up the plans for these model tenements. The building work has been done by the Ferro Concrete Construction Co., Cincinnati, Ohio.

* * *

AMERICAN METRIC ASSOCIATION

The American Metric Association has been formed to further the use and adoption of the metric system of weights and measures, made legal for all transactions by Act of Congress in 1866. The officers are: president, George F. Kunz; vice-presidents, William J. Schieffelin, E. P. Albrecht, and O. E. Stanley; treasurer, Arthur P. Williams; and secretary, Howard Richards, Jr.

In stating the purpose of the American Metric Association, an address by Hon. William C. Redfield, secretary of commerce, before the Philadelphia Chamber of Commerce, January 10, 1917, is quoted, in part, as follows:

> The fact, of course, is that the metric system adopted by thirty-four nations is simpler, easier, more effective and more widely used than any other. It has made its way by its merits. Nobody wishes it to make its way by any other means. There is no argument for the retention of our present system of weights and measures that is not an argument against our decimal system of currency. No reason supports our decimal system of currency that does not support a decimal system of measures. This handicap we must throw off, not necessarily at once, but by adopting some reasonable method as an evolution out of darkness toward light—out of foolishness toward reason.

Membership is open to those in sympathy with the objects of the association. The annual dues, payable in advance, are $2 a year for individuals; $5 a year for firms and corporations; and $10 a year for organizations. Life membership is $50 for individuals and $100 for other classes of members. The association has headquarters at 156 Fifth Ave., New York City. Applications for membership should be sent to Howard Richards, Jr., secretary, at that address.

* * *

CONSOLIDATION OF PUBLISHING HOUSES

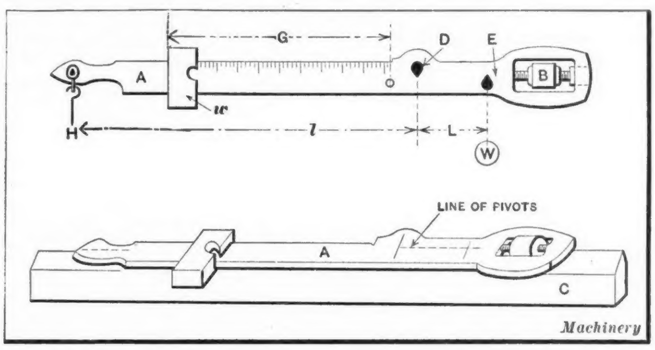
The McGraw Publishing Co., Inc., and the Hill Publishing Co., both of New York City, have consolidated as the McGraw-Hill Publishing Co., Inc. The new company acquires the *Electrical World, Electrical Merchandizing, Electrical Railway Journal, Engineering Record, Metallurgical and Chemical Engineering, The Contractor, American Machinist, Power, Engineering News, Engineering and Mining Journal* and *Coal Age.* The *Engineering News*, owned by the Hill Publishing Co., and the *Engineering Record*, belonging to the McGraw Publishing Co., Inc., will be joined in one publication known as the *Engineering News-Record.* The officers of the consolidated concern are James H. McGraw, president; Arthur J. Baldwin, vice-president and treasurer; E. J. Mehren, vice-president and general manager.

LETTERS ON PRACTICAL SUBJECTS

We pay only for articles published exclusively in MACHINERY

PRESSURE ON A SCALE BAR

Referring to the inquiry by R. J. T., concerning the pressure on a scale bar, in the February number of MACHINERY, a scale maker would first attach to the short arm of the scale beam *A* a balance ball *B* heavy enough to counterbalance the long arm when the poise is at zero. Then he would balance the beam over a knife-edge *C*, placed lengthwise, in order to find the neutral axis. He would mark this line and set the pivots *D* and *E* with their edges on the mark. The metal will now



Diagrams illustrating Pressure on Scale Bar

be equally distributed to the right and left of pivot *D* and above and below the pivot line. This disposes of the troublesome factors w_1, w_2, and l_1, l_2, and LW will equal lw. The weight of the poise w may be found by either of the following formulas:

$$G : L = W : w$$

$$w = \frac{\text{Pounds per inch of marking} \times l}{X_n \text{ at } H}$$

in which G = "run," or length of graduated portion;
L = distance between pivots;
W = load on pivot E.

X_n is the "multiplication," or relation between the counterpoise weights and the load on platform: that is, if it requires ½ pound at H to balance 100 pounds on the platform, X_n is 200. If the beam is attached to a scale having multiplying levers, then W is the load on the platform divided by X_n of scale levers.

Rutland, Vt. W. H. SARGENT

SETTING UP HEAVY MACHINERY

In the installation of a new flanging press recently, the management of a metal-working plant found itself confronted with a serious problem. Though four ten-ton cranes served the floor where the new press was to be erected, their combined lifting capacity was only forty tons, if the nominal ratings were observed, and not over fifty-five tons if they were overloaded to the limit. In addition, it was practically impossible to hitch all four cranes to the load so that each would take its equal share of the strain; and even if this were feasible there still remained twenty-five tons of iron to be handled in some other way, as the main frame casting of the press weighed a little over eighty tons.

A standard gage railway spur that entered one end of the plant for handling incoming materials was continued down the shop nearly to the site for the new press, where it was divided and a line placed on each side of the press foundation. The heavy casting was then shunted in on a special car, because of its bulk and weight, and "spotted" just beyond the foundation. Two railroad wrecking cranes of sixty and eighty tons' capacity, obtained from the nearby division ends of two railroad systems, were then run into the plant—one down each switch. Hitches were taken on the casting and it was unloaded and lowered on its foundation; the actual time the hitches were on the casting was a little over forty minutes.

The cranes were charged for at the rate of $16 and $20 an hour, respectively, the charge being computed from the time the units left the railroad yards until they returned. But the cost of placing the press was so much less than would have been incurred by any of the other methods suggested that the management felt that an appreciable saving in cost—not to mention the additional working time of the press gained by the quick set-up—was obtained by this method.

Pittsburg, Pa. CHARLES C. LYNDE

PROTECTOR AGAINST BLOTTING

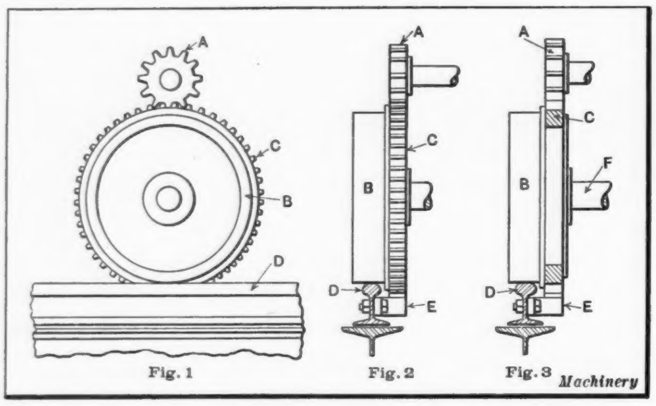
The barrel stave as an educational appliance applied to the ignoble portion of a recalcitrant youth is too little used; but as an accessory to the drawing-board to prevent blotting or smudging, as suggested by A. P. Connor in the February number of MACHINERY, the writer would prefer a T-square with two strips of cork affixed to the under side of the blade by drafting tacks, or even with two thick rubber bands, snapped around it. Anyway, no man with jiggly hands is fit to be a draftsman. R. G.

FAULTY GEAR AND RACK CONSTRUCTION

Often a mistake in design will go through the drafting-room and be incorporated in the completed machine for some time before it is noticed. The machine, on account of this, may give some unlooked-for results and attract attention, but the real seat of trouble may not be suspected. It will be known that there is something wrong and the chances are that a hundred different persons noting the trouble will advance as many theories as to the cause. These mistakes usually turn out to be such simple and foolish things that, after their discovery, we wonder how in the world they were made.

A mistake of this nature is here given. Figs. 1 and 2 show side and end elevations of a track wheel which it was found advisable to drive positively, because of the slippery condition of the track, rather than rely on the uncertain traction between track and wheel. The wheel is driven by pinion *A* meshing with gear *C*, which is integral with the flanged wheel *B*. Parallel to the track *D* runs a rack *E* with which gear *C* meshes, thus forming a positive drive for the track wheel, which merely supports the load. More than the estimated energy was required to move the machine supported by these wheels, and after this apparent oversight had been checked the power allowed was found to be ample; but it was not sufficient to run the machine properly. The first hint of the trouble came from the shearing of the key in pinion *A*. Investigation of the parts beyond this pinion, where the trouble was obviously located, revealed the following conditions: The outside diameter of wheel *B* was 15 inches. The pitch diameter of the driving gear was 15¾ inches. Therefore, during one revolution of the gear the machine was moved forward a distance equal to the pitch circumference of the gear or about 49½ inches. But as the diameter of wheel *B* was only 15 inches, one revolution of this wheel meant only a little more than 47⅛ inches of travel; hence, the load on each wheel was dragged about 2⅜ inches for each revolution of gear *C*.

This condition was remedied by making gear *C* revolve upon a sleeve of the wheel *B*, as shown in Fig. 3, where gear



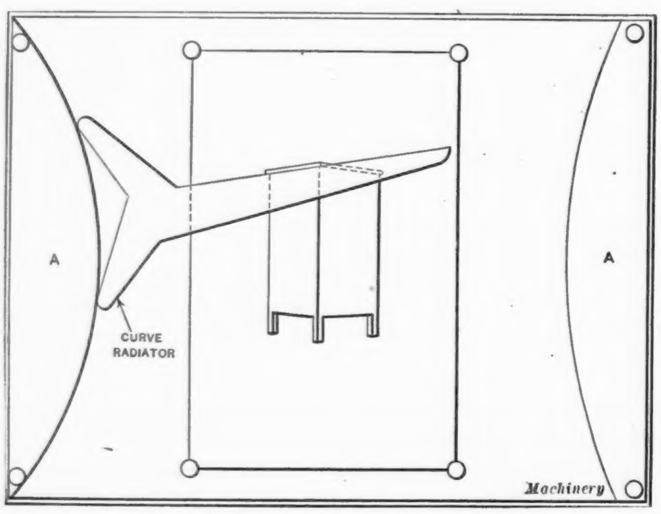
Figs. 1 to 3. Faulty and Improved Gear and Rack Construction

C is idle on wheel *B*, which is keyed to shaft *F*. A short study of this arrangement will show that it also has objectionable features, for the pressure of gear *C* against axle *F* as a fulcrum is equal to twice the force necessary to revolve the gear. Work is therefore dissipated through a part of each revolution due to this force on the gear bearing and consequent friction between the bearing surfaces at a large diameter. The best arrangement would have been to have made the wheel diameter and pitch diameter of the rack gear the same.

Otto Abdt

PERSPECTIVE DRAWINGS

The making of perspective drawings is generally termed a "deuce of a job" and often an isometric or some other distorted angular projected view is made to serve the purpose. Isometric drawings are satisfactory for working drawings, but for patent-office work and other cases where appearance is a great factor the true perspective is preferable. This, however, brings with it a nightmare of centrolineads or the expedient of putting the vanishing points within the limits



Making Perspective Drawings with Curve Radiator

of the drawing-board, which may give an unnatural viewpoint and hence a distorted picture of the article represented, especially if one is working with an 18- by 24-inch drawing-board.

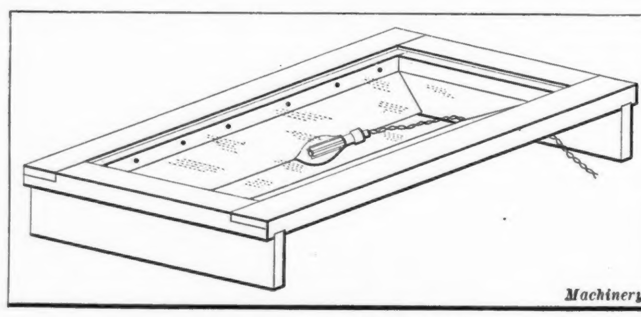
The following kink will perhaps be useful to many draftsmen, when making patent or other small drawings. First, cut a sheet of drawing paper about one-quarter inch smaller than the drawing-board. Then, from three-sheet bristol board, cut two pieces curved as shown at *A*. These should be free from irregularities, but their radii can be made to conform to each draftsman's taste in vanishing points; the centers from which the radii are drawn form the two vanishing points of the drawing. Paste these two pieces upon the sheet of drawing paper, being careful that the edges are down close; then when dry tack the paper upon the board and set true by means of the center line.

By using a curve radiator against the bristol board, the vanishing lines from each side may be obtained without the trouble of changing the arms, as when a centrolinead is used, while the thickness of the bristol board, 0.01 inch, offers no obstacle to the use of the T-square or triangle for parallel lines. For constant use, the curves may be made of stiffer and more durable material that will lie flat, and holes may be drilled in it for thumbtacks. A few moments' study of the figure will give a good idea of the manner of using this device.

East Orange, N. J. B. E. Barnes

TRACING FRAME FOR BRISTOL BOARD

The frame shown in the accompanying illustration has been found useful for tracing on bristol board. Recently the writer had to reproduce twelve Van Dyke drawings on bristol board for a patent application; by using this frame, the work was done in less than one-half the time it would have taken to lay it out. The frame is also useful for tracing the outline of a machine previously patented, on which an improvement is to be made. The construction is simple. A rabbet along the inner edges of the frame holds a pane of glass, which in this case is 8¼ by 13¼ inches, the size of a patent sheet. Tin is then tacked on both sides of the frame and inclined at an



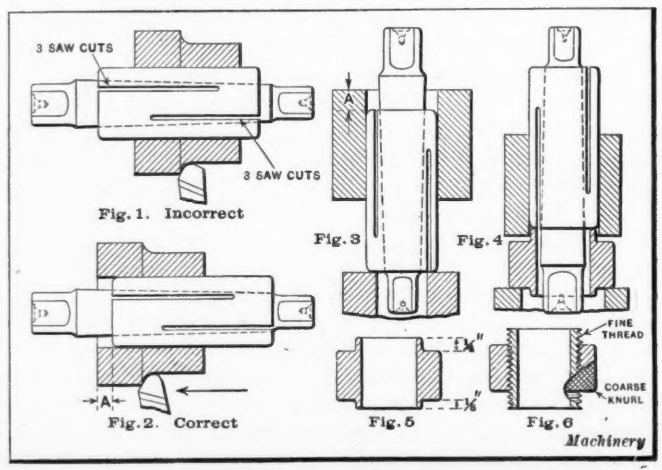
Tracing Frame for Bristol Board

angle of 45 degrees to reflect the light where it is most needed. At first the writer used a carbon lamp, but it was found that a Mazda lamp gave better light and less heat. Of course the room must be darkened when the frame is used.

Cincinnati, Ohio Harry W. Davis

USE AND ABUSE OF EXPANSION MANDRELS

In most shops where the split bushing type of expansion mandrel is used, a great number of bushings are damaged by being cut with the tool when facing the work, are broken into pieces, or are out of true. These conditions are generally brought about by inserting the bushing and arbor as shown in Fig. 1, thus leaving the bushing unsupported at the large end of the tapered hole. The correct position of the bushing and arbor is shown in Fig. 2. After the hole is bored and one end is faced in the usual way, the split bushing is inserted by hand with the large end of the tapered hole toward the un-



Figs. 1 to 6. Correct and Incorrect Methods of using Expansion Mandrels

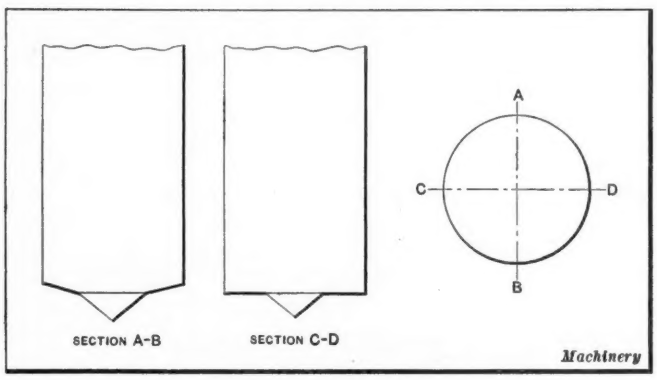
faced end of the work. As the distance A, Figs. 2 and 3, is a little more than the amount to be faced off, it supports that part of the bushing where the greatest pressure occurs; it also provides clearance for the tool when facing, and eliminates the danger of cutting the bushing. The taper arbor is driven or pushed in as shown in Fig. 3.

To withdraw the arbor, special bushings are used in the manner shown in Fig. 4. The small expense incurred by making a few special packing bushings, as shown in Fig. 5, or the adjustable ones shown in Fig. 6 will soon be repaid, when once made, for they are practically indestructible. These bushings should be stored with and handed out with the arbors and split bushings. The two dimensions given in Fig. 5 have proved convenient for most sizes of work, though other dimensions may be made as required. The travel of the tool, when turning diameters, should always be in the direction of the arrow shown in Fig. 2.

F. H. C.

HEAVY-DUTY PUNCH

The heavy-duty punch with a 90-degree teat, shown in MACHINERY for January, would be improved by grinding off the face from two opposite sides toward the teat, forming two



Heavy-duty Punch

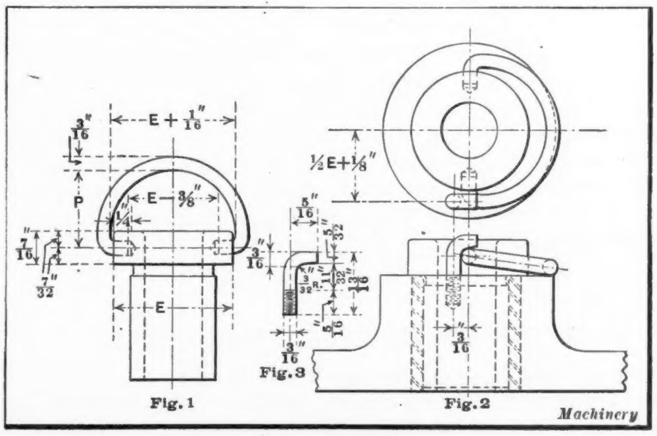
slanting surfaces, as shown in the accompanying illustration. The punch will grip the plate nicely and start easily, instead of requiring all the power at once. Where the two oblique planes meet, the line should be eased off a bit.

New York City ROBERT GRIMSHAW

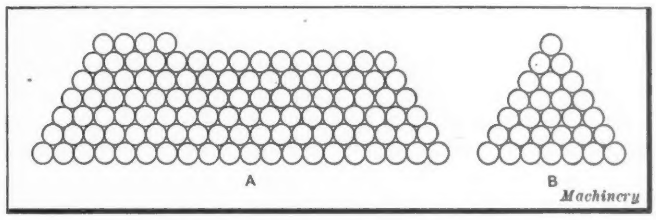
SLIP BUSHING

There is a type of slip bushing in fairly common use that the writer has not seen illustrated or mentioned in any books on jigs that he has read, and yet it is cheaply made and a great deal more easily handled and clamped than the knurled-head type. Fig. 1 shows the bushing in the handling position. The dimension P can be taken as one-half E plus ¼ inch, but it should never be less than 1 inch in order to allow room for the finger to be inserted. Fig. 2 shows how the bushing is clamped in operation. When it is flat against the work, chips forced up the flutes of the drill cannot lift the bushing out of place. Fig. 3 gives the dimensions of the clamp hook.

Philadelphia, Pa. HARRY S. KARTSHER



Figs. 1 to 3. Cheap, Handy Slip Bushing



Rapid Method of counting Pieces in a Pile

COUNTING NUMBER OF PIECES IN A PILE

In the December number of MACHINERY there is presented a method for determining the number of pieces in a pile without actually counting them. This method may be simplified as follows: Add the number of pieces in the top row to the number of pieces in the bottom row and multiply the result by one-half the number of rows. To this result add the odd number, if any, at the top of the pile. This can be stated as a simple formula:

$$S = (T + B)\frac{N}{2} + O$$

in which S = total number of pieces;
T = number of pieces in top row;
B = number of pieces in bottom row;
N = number of rows;
O = number of odd pieces at top of pile.

For example, in the case shown at A, $T = 15$, $B = 20$, $N = 6$, $O = 4$. Inserting these values in the formula and solving,

$$S = (15 + 20)\frac{6}{2} + 4 = 35 \times 3 + 4 = 109$$

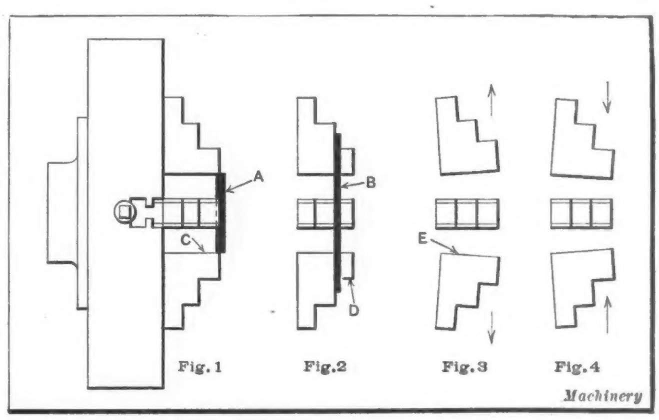
In the case shown at B, $T = 1$, $B = 7$, $N = 7$, $O = 0$. Inserting these values in the formula and solving,

$$S = (1 + 7)\frac{7}{2} + 0 = 8 \times \frac{7}{2} + 0 = 28$$

Flint, Mich. J. W. McDADE

REGRINDING CHUCK JAWS

The truing of lathe chuck jaws, which are usually hardened and therefore require grinding, is an operation that must be performed frequently, especially when the chucks are used



Figs. 1 to 4. Methods of regrinding Chuck Jaws

on accurate work. Some of the errors usually made when doing this work can be easily avoided by a little care. When new, the jaw is a free sliding fit in the body of the chuck; and if worn much, from constant use, it sometimes becomes very loose. For this reason, if the stress on the jaws is similar to that indicated in Fig. 1, they assume a shape like that shown (exaggerated) in Fig. 3; if the stress is like that indicated in Fig. 2, the result is as shown in Fig. 4.

If surface C is to be trued, the usual way is to chuck a ring by the inside as shown at B. The stress on the jaws is then as indicated by the arrows in Fig. 4, and all the pressure will be at point E, and not distributed along the length of jaw as it should be. A better method is to chuck a smaller ring, as shown at A, and grind up as close to it as conditions will permit. Afterward, the jaws may be taken out of the body

and the small surface covered by ring *A* ground, either by the use of a small cutter grinder or free hand, the previously ground surface being used as a guide. In the same way, if it is required to true up the steps *D* for inside chucking, the stress on the jaws, while it is being done, should be as indicated in Fig. 4, or similar to that existing when the chuck is actually in use. The ring *B* used for this purpose can be made very thin, so that the surface covered by it will be small and easily removed later.

Philadelphia, Pa. A. Dane

FIVE-OPERATION COMBINATION DIE

The combination die described in the following performs five distinct operations in the making of the cup shown in Fig. 2. This die is comparatively simple in construction and yet is very effective for manufacturing cups like that illustrated, although limited somewhat in the thickness of metal of which the cups may be made. In this case, the cup is made of a good quality of tin, 0.008 inch thick. It is half of a float for indicating the oil or gasoline level in automobile engine crank-cases or gasoline tanks.

The die, Fig. 1, is intended for use in a simple single-stroke power press, the operations of blanking, forming, piercing, embossing and trimming all taking place consecutively or simultaneously. For the best results the die is preferably made of the four-post type, thereby affording accurate alignment for the upper and lower working members. As the upper member descends, a circular piece a little larger than the required size is blanked out, leaving about 1/16 inch to be trimmed off the edge, thereby giving uniform depth. This blanking is done by the punch *A* entering the die *B*. As the upper member descends farther the spring pad *C* is forced downward and the blank contacts with core *D*, which commences the cupping. The inside edge of punch *A* forces the metal over core *D*, and knockout *E* recedes as the punch descends. Just before the end of the stroke, the excess metal from the lower edge of the cup is sheared or pinched off between the edge of core *D* and the internal radius *b* on punch *A*, thereby accurately trimming the cup. This method of trimming is employed in jewelry manufacture in making shallow cups at one stroke of the press. These tools are generally known as pinch tools. The ring of scrap which is removed from the edge of the cup in trimming is raised to the surface at the up stroke of the press by the spring pad *C* together with the cup. At the end of the stroke the punch *G* pierces and embosses the small central hole in the cup. The scrap drops through a clearance hole in the core into the scrap pan. It is important that the radius *b* on the inside of the punch be as small as possible without causing the metal in the cup to wrinkle or pull excessively when drawing. The more nearly this radius approaches a square corner, the more positive is the shearing action when the cup is being trimmed.

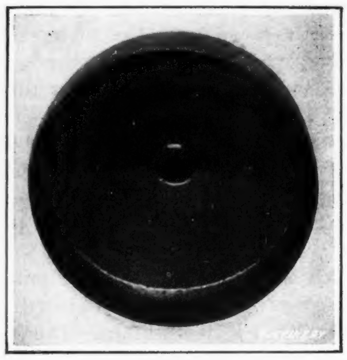


Fig. 2. Cup made in Die shown in Fig. 1

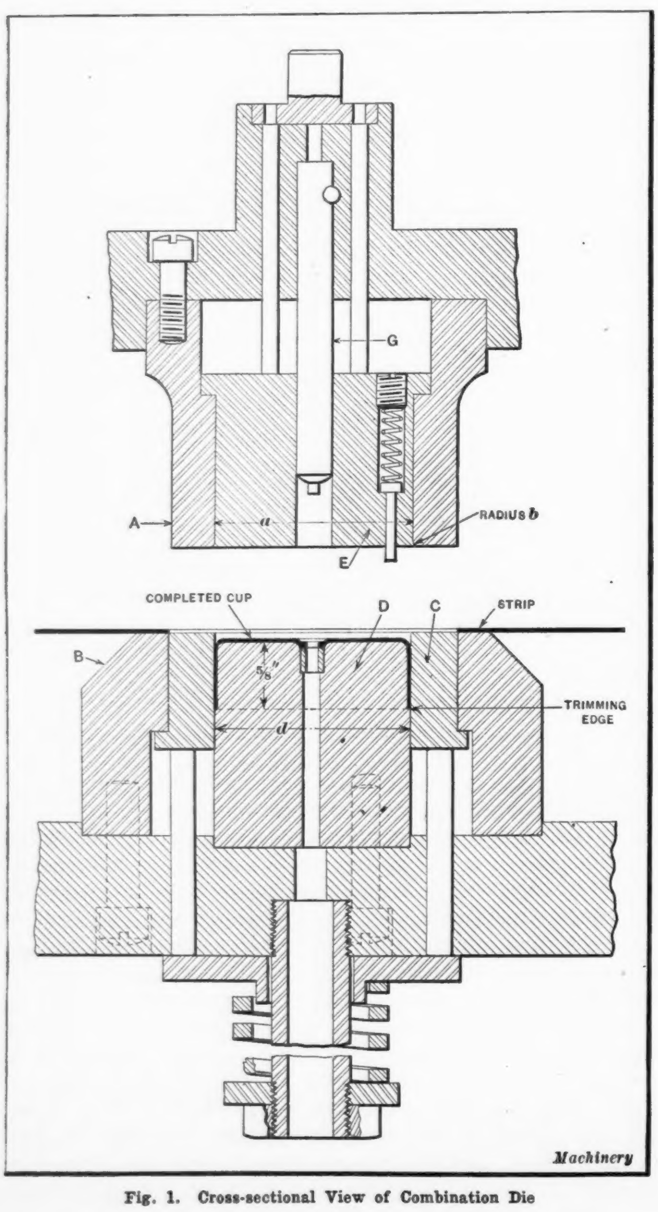


Fig. 1. Cross-sectional View of Combination Die

A few of the dimensions of this die must be very accurate to make it a successful working tool. For instance, the diameter *a* of the hole in the punch should not be more than 0.0005 inch larger than the dimension *d* of core *D*. This is essential to insure the correct trimming action of the die. Except as previously described, this tool is similar in general construction to any other well designed die. It is essential that most of the working faces be highly polished. Compressed air and a spring pin knockout, together with the positive knockout, are used for removing the completed cup and scrap at each stroke of the press. The die operates successfully in a press making between 75 and 85 revolutions per minute, and when accurately made will turn out many thousand pieces without attention.

Ypsilanti, Mich. A. E. Sanford

SECOND ANNEALING OF FORGINGS

Much care is being taken in many shops to obtain correct feeds and speeds in order to produce maximum output with minimum labor cost, but the economy of second annealing is generally overlooked. Often small parts that have been forged and annealed in the blacksmith shop and sent to the machine shop are found to be difficult to machine. If a light roughing cut is taken and they are again annealed, the machining is more easily accomplished. In one case, as soon as a quantity of grinding-wheel spindles was received from the blacksmith shop, one was put in the lathe and centered; when the first cut was taken, the spindle ran out of true and had to be straightened. After being straightened, it was again put into the lathe, but cutting a thread on it was still very difficult. Because too much time was occupied in machining, it was decided to take a slight roughing cut off all the spindles and then anneal them. By taking a light cut before annealing, the strain was taken off the pieces and the thread was cut in about one-third the time; besides, a much better job was produced.

New Haven, Conn. Eric Lee

FOUR-GEAR EPICYCLIC TRAIN

In the March, 1916, number of Machinery there appeared an article entitled "Four-gear Epicyclic Trains," which described two types of gears, one "imperfect" and the other "mechanically perfect." The latter was a train composed

wholly of gears with a standard tooth and space. No doubt this is more to be desired, in some instances, than what is known as a mongrel tooth. The writer takes exception, however, to the statement regarding the imperfect mechanism which was here described as the nearest approach to the perfect. This mechanism was shown with a planet pinion mounted on a pulley and in mesh with two gears of different pitch diameters, which causes great wear on the teeth as well as a prohibitive amount of backlash, not to mention noise.

The gear shown in Fig. 1 was designed, and twelve units have been built, for use in connection with a chucking machine. This supplied the power for feeding an 11/16-inch drill through eight inches of chrome-nickel steel. Fig. 1 shows the driving pulley, together with the cast-iron casing that completely encloses the gears and forms an oil-tight case. With the proper oil channels, this construction provides lubrication for all parts subject to wear.

For purposes of explanation it will be assumed that all gears are cut with 10-pitch cutters and, with the exception of gears *A* and *F*, have a standard form of tooth and space. Gears *A*, *D*, *F*, and *G* have a pitch diameter of four inches. Gears *D* and *G* have the required forty teeth, while *A* and *F* have thirty-nine teeth. Gear *G* is keyed to the shaft *O*. Pinions *B*, *C*, and *E* have a pitch diameter of 1.5 inch and have fifteen teeth. Gears *A* and *F* have long hubs extending into the support, these hubs being pinned together as a unit. The screw *S* locks the whole integral with the support to prevent turning. The web of the pulley contains a boss into which is forced a bronze bushing that acts as a bearing for the shaft to which are keyed pinions *B* and *C*. The pulley revolves on the long hub of gear *F*, the bronze bushing taking the wear. Plates *H* and *K* are joined rigidly by the segment blocks *R*, Fig. 3. These plates contain bronze bushings in which revolves the shaft to which pinion *E* is keyed. This unit is screwed and doweled to gear *D* through plate *H*.

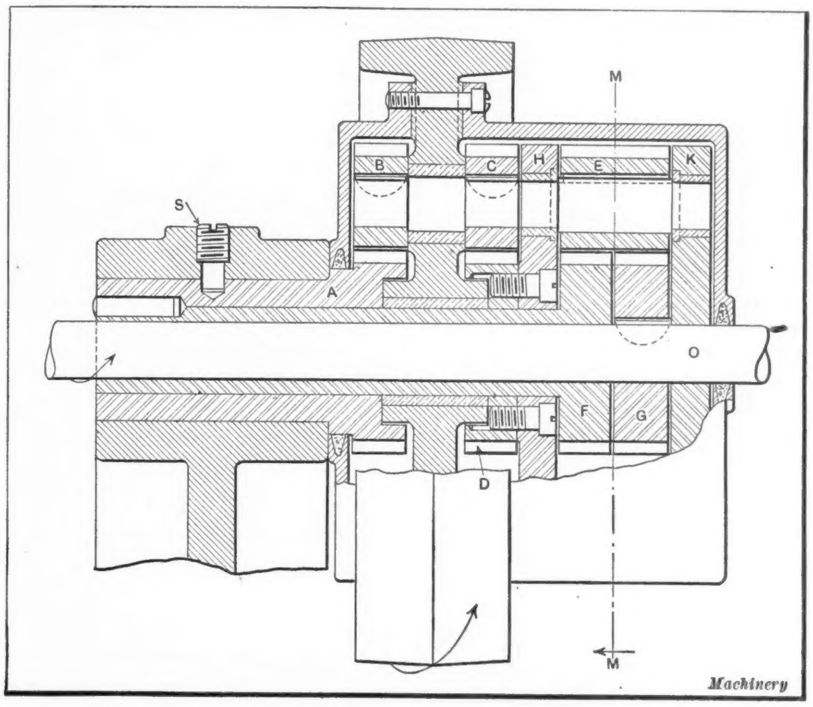


Fig. 1. Longitudinal Section of Four-gear Epicyclic Train

As gears *A* and *F* have thirty-nine teeth, they will have a corresponding circular pitch of $\frac{4\pi}{39} = \frac{4\pi}{40} + \left(\frac{4\pi}{40} \div 40\right) = 0.322$ inch, while the circular pitch of *D* and *G* is $\frac{4\pi}{40} = 0.314$ inch, giving a minimum backlash of 0.008 inch per tooth. It is evident that as the pitch is increased, the backlash is decreased proportionately, and *vice versa*. It is shown in Fig. 2 that as the pulley revolves and pinion *B* passes over each tooth of *A*, gear *D* is moved the difference between the circular pitch of these two gears, or 0.008 inch. One revolution of the pulley will advance this gear one tooth, and forty revolutions will produce one complete revolution of *D*, which being connected to pinion *E* of the second unit, through *H* and *K*, causes gear *G* to advance one tooth. As a result, to produce one revolution of shaft *O* the pulley must make 40 × 40 = 1600 revolutions.

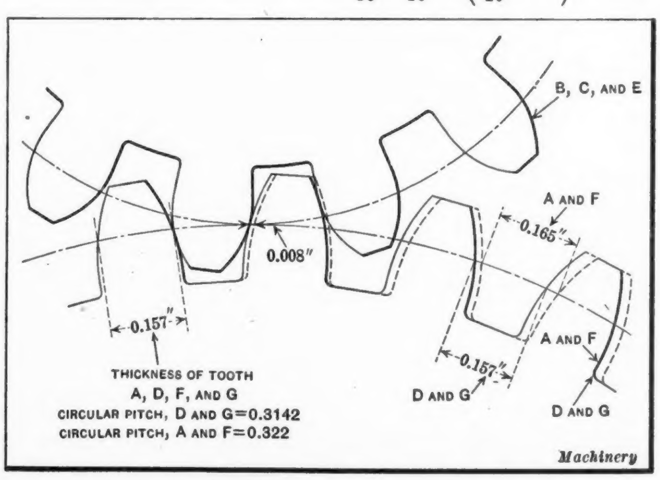


Fig. 2. Showing Differential Action of Epicyclic Gears

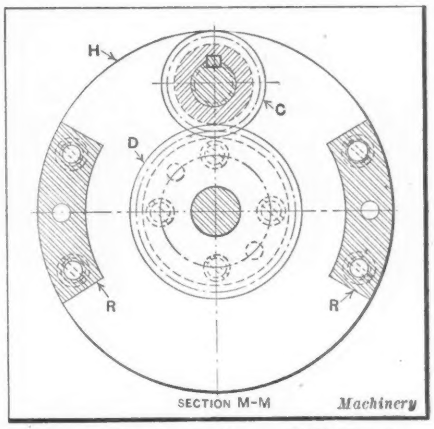


Fig. 3. Showing Section on M-M, Fig. 1

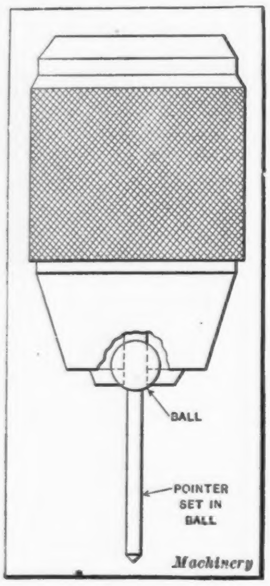
It is quite practical, if occasion requires, to extend this gearing by the addition of more units, which will greatly reduce the diameter but will slightly increase the length. The possibilities of a large reduction are unlimited. One big advantage of this type of reduction is the facility with which the gears may be chosen for known reductions. If this is of such proportions as to prohibit the use of a single unit, on account of the large diameter required, the square root or cube root of the reduction may be taken and two or three units used, thus reducing the diameter, as stated. The root is always the reduction ratio of one unit, and represents the number of teeth in gears *D* and *G*. For this reason it must be a whole number.

If it should be necessary, the driving pulley and shaft *O* may be made to run in opposite directions by transposing the number of teeth in the stationary and the movable gears. The former in that case will have forty teeth and the latter thirty-nine. Because of its compactness and the small amount of attention necessary, when provided with a proper oil opening for refilling, this gear seems to be especially fitted for hard usage where great reduction is necessary.

Hartford, Conn. A. S. Burrill

LOCATING WORK FOR BORING

The boring of a hole accurately in a certain position is one of the things in machine construction that requires both care and skill. It is only natural, therefore, that quite a number of devices have been developed for facilitating such operations. The December number of Machinery describes a tool with which satisfactory results have been secured. The method is to designate the location of the hole in the work by means of accurately scribed lines on the face where the hole is started. The work is then set up square and parallel on the



Pointer used for locating Center

milling machine and the intersection of the lines made to coincide with a pointer that, by means of an indicator, has been adjusted so that the point is known to run true with the boring spindle. Good results can be obtained in this manner, as when the surface is properly prepared fine, clean lines from a height gage or a scribing block will be close enough for quite accurate work. In the final polishing before marking, the grain should be laid so that it will not run parallel with the lines to be marked, as that will make them difficult to see; and by using a glass it is quite possible to set the lines on the work to coincide with the accurately adjusted point. It has been found by experience that work can be kept within ± 0.001 inch by such a method. In the illustration is shown the tool which the writer uses in locating work by the above plan; this has the merit of being very easy to make and use. It is made from a steel ball, 1/4 or 5/16 inch in diameter, that is annealed and drilled for the rod that is to act as the pointer. The simplest way of drilling this hole is to hold the ball in the draw-in chuck in the bench lathe. When drilled, the ball is rehardened. In the case of a 1/4-inch ball, the writer has made the pointer from 0.08-inch drill rod about 1 3/4 inch long. One end of the rod is fitted to the ball and the other is turned to a 50- or 60-degree point. It is then hardened on the pointed end only. The point should be ground so that it will be sharp and true. The hole is a drive fit for the rod, so by holding the rod carefully in the vise the ball can be lightly yet securely tapped on; the tool is completed by rounding the end of the rod where it comes through the ball.

In use, this tool is held in a three-jawed chuck in the milling-machine spindle, but it should be tightened very lightly, as the pointer must be readily deflected by a gentle pressure. Then the machine is started, running on one of the faster speeds; and as the work on the table is moved close up to the pointer, the hand is carefully steadied and, by a gentle pressure of the thumb-nail, the point of the tool is brought into its true position, which of course is determined by the entire absence of any side movement of the point. This should be verified by means of a glass. Then with the spindle still running, the work is brought almost in contact with the point and moved up, down and sidewise until the lines are exactly located; a glass should also be used for this purpose.

While the tool is very simple to make and use, the writer prefers it to the various more or less complicated adjustable instruments that have been suggested for locating holes by lines on the milling machine. But for satisfactory results, the lines must be sharp and clean; prick-punch marks must not be placed where the centers come, the lines themselves must be used; the chuck should be tightened very lightly; the pointer must not touch the work; and the machine used should not stand on a weak, shaky foundation.

Woonsocket, R. I. ARTHUR W. SUITER

MULTIPLE KEYWAYS IN MILLING CUTTERS

I have seen milling cutters made with three keyways in the bore, the purpose being to increase the length of time between grindings. The operator is instructed to mount the cutter on the arbor first with No. 1 keyway engaged with the key; then, when the teeth become somewhat dull, to change to No. 2 keyway; and then again to No. 3. The theory is that the teeth of a milling cutter approximately opposite the key always cut deepest and dull first because of the clearance of the cutter hole on the arbor. Thus, by changing the position of the cutter on the arbor in succession, the teeth are dulled equally all around, and the life of the cutter between sharpenings is increased. The scheme is one that could be used probably with satisfaction by careful operators, but even then I doubt if the gain would pay for the trouble of loosening the arbor nut and changing the cutter position on the driving key in order to lengthen the life between grindings. It seems as though the gain would be small.

But the idea of three keyways in the cutter suggests the question: why not cut four keyways in all milling cutters and provide multiple spline arbors to drive them? There would be no sheared keys and the drive would be stronger than with the present common single key arrangement. The cutters would run with less eccentricity, do better work and revolution marks on finished work would not be so common.

M. E. CANEK

COLD-ROLLED STEEL SHAFTING

In answer to the request in the February number of MACHINERY for information on cold-rolled steel shafting, the writer would call attention to the tests made by Prof. R. H. Thurston of Cornell University in 1902. The results of these are published in Jones & Laughlin Steel Co.'s catalogue of power transmission machinery. According to these tests, the elastic limit is increased from 15 to 97 per cent and the tenacity from 20 to 45 per cent. The resistance to transverse loads is increased from 11 to 30 per cent at the elastic limit, and from 13 to 69 per cent at the yield point. Resistance to torsional stress is increased at the elastic limit from 28 to 40 per cent, and at the yield point, from 31 to 64 per cent; at the point of fracture there is a decrease of from 4 to 10 per cent. Professor Thurston says that the effect of cold-rolling extends undiminished to the center of a bar. The results of tests with bars that were turned down from 1 3/4 inch in diameter are given in the accompanying table.

Pittsburg, Pa. B. OLSEN

RESULTS OF TESTS ON COLD-ROLLED AND HOT-ROLLED STEEL BARS

Diameter of Bar, Inches	Load, Pounds per Square Inch				Elongation in 8 Inches, Per Cent	Reduction of Area, Per Cent	Resilience, Pounds Per Cubic Inch		Modulus of Elasticity
	Elastic Limit	Yield Point	Maximum	Ultimate			Elastic Limit	Ultimate	
Cold-rolled Steel									
0.349	54,000	62,500	73,637	51,613	7.50	53.70	48.14	5,600	30,393,000
0.526	59,500	66,000	75,739	55,060	10.12	54.10	56.21	7,340	31,560,000
0.772	53,500	66,000	76,636	54,548	12.31	55.70	47.02	9,000	30,476,000
1.019	52,000	62,000	73,778	50,205	14.87	57.80	42.25	10,480	30,056,000
Hot-rolled Steel									
0.355	30,000	35,250	58,606	40,164	22.06	68.0	15.32	10,900	29,418,000
0.509	31,900	35,500	58,809	41,569	24.31	61.7	17.51	12,860	29,073,000
0.754	29,750	35,750	59,747	41,793	29.25	64.2	15.67	15,280	28,337,000
1.010	30,250	35,250	61,210	43,392	30.00	63.8	14.43	16,740	29,126,000

Machinery

CHAMFERING PINS IN AUTOMATIC SCREW MACHINE

In chamfering pins in automatic screw machines, a production of 8100 a day, four seconds for each pin, as given in the January number, seems slow. When the writer had Bessemer steel wire spindles to cut off with the tool arrangement there illustrated, he ran the machine at the rate of two seconds for each piece, with a net daily production of 16,200, which is just double the speed mentioned; and they had to be cut off without much of a teat showing. The writer made 200,000 pieces at that rate; but as this is faster than the machine is scheduled to run, the next time this job came through it was run at the rate of one piece every three seconds (the fastest listed speed of the machine). The two-second speed was obtained by compounding the gears. The cutting-off tool was fed at 0.001 inch per revolution, and the 200,000 pieces were made with no trouble. A straight high-speed steel cut-off blade was used as close to the collet as possible. The cams could have been made with double lobes (giving a production of four seconds for two pieces) but for the fact that the limit in length was too close, being $\pm$ 0.001 inch, and it is difficult to get the lobes of the lead cam exactly the same height.

Bayonne, N. J. JOHN NEUPAUER

THEORY OF ENLARGED HERRINGBONE PINIONS

The article entitled "Theory of Enlarged Herringbone Pinions" in MACHINERY for January, advocated enlarging the pitch diameters of both the gear and the pinion, which increases the center distance and the pressure angle. The result is a new pair of gears and, in the example there given, a pair of gears of odd pitch, odd pressure angle, and odd center distance. The writer of that article proceeded by finding a new pitch diameter for the pinion that entirely avoids interference with the standard addendum rack tooth, and then gave to the gear a proportionately larger pitch diameter. This gives a new and larger center distance and, since the base circle diameters remain the same, there is also a larger pressure angle.

The formula suggested there for finding the new pitch diameter gives a pressure angle that is higher than necessary to avoid interference. The formula given was as follows:

$$\frac{\text{Number of teeth}}{\text{Diametral pitch}}(\cos \text{ pressure angle})^2 + \frac{2}{\text{Diametral pitch}} =$$

nominal pitch diameter.

In Fig. 1 are shown the pitch circle for a 20-degree pressure angle and the new pitch circle given by this formula. It will be seen that the interference line for the rack given by the new pitch diameter is within the original interference line. This is not taken care of in the formula and results in a pitch diameter and pressure angle that are unnecessarily high. The addendum could be made equal to the dimension A, which would be greater than standard, and still avoid interference.

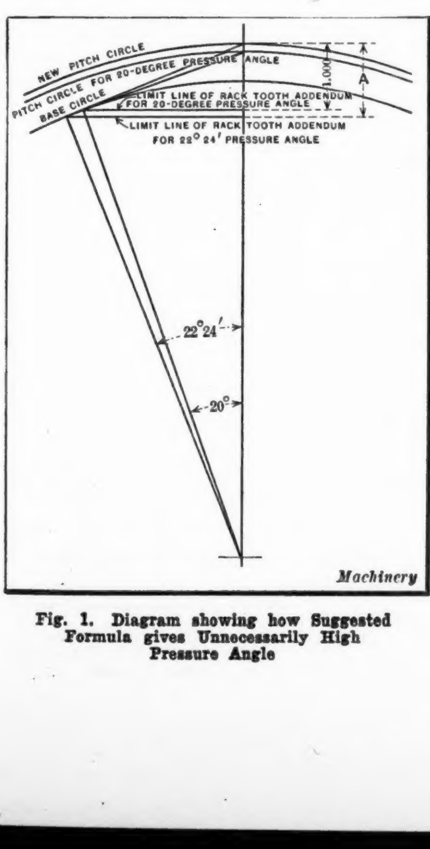


Fig. 1. Diagram showing how Suggested Formula gives Unnecessarily High Pressure Angle

It seems to the writer that a much better way to solve the problem of interference would have been to find the lowest pressure angle at which the fifteen-tooth pinion would mesh with the standard addendum rack without interference. The standard center distance and the standard pitch can then be maintained, which is an obvious advantage. The formula for finding the lowest pressure angle at which a gear of any number of teeth will mesh with a rack of standard addendum without interference is obtained as follows: From Fig. 2,

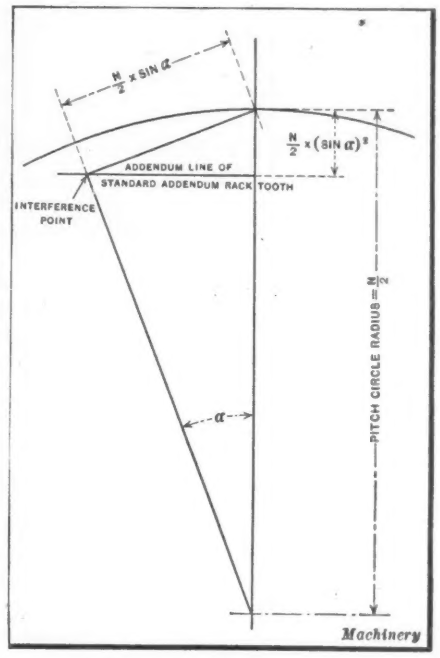


Fig. 2. Diagram showing how Pressure Angle that avoids Interference is determined for Any Number of Teeth

$$\text{Maximum addendum of rack} = \frac{N}{2}(\sin \alpha)^2$$

where N = number of teeth and α = pressure angle. When the addendum is standard, the formula becomes $\frac{N}{2}(\sin \alpha)^2 = 1$, from which $(\sin \alpha)^2 = \frac{2}{N}$, or $\sin \alpha = \sqrt{\frac{2}{N}}$. For fifteen teeth, the angle α is 21 degrees, 25 minutes, whereas the formula suggested in the article referred to gives α as equal to 22 degrees, 24 minutes.

The difference between the results obtained by these formulas is that the formula here presented gives the exact results sought, *viz.*, the lowest possible pressure angle with the elimination of interference, while all other dimensions are unchanged; whereas the other formula gives an unnecessarily high pressure angle and changes the center distance and pitch. Excessive sliding action, and the consequent excessive wear on the pinion tooth faces, is avoided in both cases, but this is not quite so important as it might seem since the pinion is almost invariably the driver; therefore, the pinion faces only come into contact on the arc of recess and, when the sliding action is greatest, the load is shared by another pair of teeth being in contact.

Auburn, R. I. ARTHUR BROWN

HARDENING PLUG GAGES

With reference to the article on hardening plug gages made of straight carbon tool steels, in the February number of MACHINERY, the writer would suggest the following method: Place in a pot like that used for cyanide hardening two parts rock salt and one part chloride of barium, and heat to 1525 degrees F., as shown by a pyrometer. Preheat the piece to be hardened to a dull red, and then immerse it in the salt solution, leaving it in the solution until it is the same temperature as the salt. Then quench it in a solution composed of one quart salt, one-half pint sulphuric acid, and ten gallons water. In dipping, the piece should be plunged straight down in the water and given a swirling motion. In the absence of the salt bath, an open charcoal fire can be used for heating, care being taken to heat slowly and uniformly to a good cherry red; the piece should then be quenched in the brine solution. It may be well to mention that "Cello Vanadium," "Ketos," and any of the ball-bearing, chrome-carbon alloys will give better results and last many times as long as straight carbon tool steels.

New Britain, Conn. WILLIAM C. BETZ

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

FORMING CARDBOARD SHAPES

E. S.—Can you give me information as to the method of making dies for cutting cardboard and the manner of forming cardboard novelties? I am particularly interested in the proper procedure to follow in blanking and forming a cardboard lid, oval in shape and one-quarter inch deep; that is, having a rim all around one-quarter inch high.

The question is submitted to readers having had experience in this line of die and press work.

BEVEL GEAR CUTTERS

A. B. G.—How are bevel gear cutters given relief on the teeth, and why are the teeth given side relief? How is the relief calculated?

A.—A bevel gear cutter is a thin spur gear cutter that differs from a regular spur gear cutter in no apparent detail except that of thickness. The standard Brown & Sharpe bevel gear cutters are made of a thickness that permits them to cut bevel gear face widths up to one-third the length of the pitch cone. Hence, the cutter is two-thirds the thickness of the standard spur gear cutter for the same pitch and number. Bevel gear cutters and spur gear cutters are not given side relief except that incident to form cutters in general which are made to be ground without changing the shape. This type of form cutter, originated by Joseph Brown, provides relief on the sides of the teeth of gear-cutters and all other form cutters in which the tops of the teeth are narrower than the base, because the tooth outline is not concentric with the axis of the cutter but eccentric to it, each tooth having its own center.

DIFFERENTIAL INDEXING

G. M. A.—Will you explain how it is possible to make 59, 60 and 61 divisions on a 39-hole circle, by moving the crank 26 holes, as given in MACHINERY'S HANDBOOK on page 926. There are several other indexings given in the table that I do not understand.

A.—The table referred to is for simple and differential indexing on the Brown & Sharpe milling machine. The divisions referred to are obtained by means of gearing connecting the dividing head spindle with the index plate. As the crank is turned, the index plate is moved slowly backward or forward, and thus the movement of 26 holes in the 39-hole circle to obtain a division of 59, for instance, is apparent but not actual. The gearing moves the index plate the fractional part of a turn required to make up the difference between 26/39 and 40/59; hence the term, differential indexing. You will note in the table that the gearing for the two divisions 59 and 61 differs, and that there is no gearing specified for 60 divisions; 60 divisions are obtained without gearing, the same as on a plain dividing head.

CARBON "POINTS" IN STEEL

E. P. P.—Which is the correct term to use in specifying the carbon content of steel, "percentage" or "points"? For instance, should we say "10 per cent" or "10 points" carbon? What is the difference between the two terms when used to designate the carbon content of steel?

A.—The point system used in specifying the carbon content of steel is based on the division of one per cent into one hundred parts; hence, in the case cited, you should say "10 points carbon," as what you mean is one-tenth of one per cent carbon and not 10 per cent. If you wish to express the carbon content in percentage in the case, say, of 50-point carbon steel, the expression should be "one-half per cent" carbon. The term "points" probably originated in an inversion of the reading of the decimal of one per cent; the decimal 0.40, for instance, was read "40-point" instead of "point 40" in order to emphasize the amount of carbon and not the fact that it was a fraction. Later the term became "points." This is used in stock quotations, but its significance varies with the commodity. When used in cotton quotations a point is one-hundredth of a cent, but when used in stock quotations it is one cent.

POSITION OF CONE PULLEYS ON LATHES

D. M. C.—Will you kindly tell why engine lathes have the large end of the cone pulley next to the faceplate, while on bench and precision lathes the large end of the cone is generally at the opposite end of the spindle?

A.—The reason that the large end of the cone pulley of a back-geared engine lathe is placed next to the faceplate is that it favors design throughout. The large spindle gear, driven through the back-gear to get the maximum torque, should be placed as near the spindle nose as possible in order to reduce torsional deflection to a minimum, and the large end of the cone should be placed close to it. Rational design calls for a larger spindle cross-section at and near the nose than at the opposite end, which means that the cone pulley bearings will be made in proportion to the spindle bearings in the headstock. Hence the large step of the cone is put over the largest part of the spindle. The reason that bench lathes are generally made with the cone pulley facing in the opposite direction is that it favors the use of the compound slide-rest when adjusted for turning angles close to the faceplate. It is possible to make much wider angle settings with the cone pulley in the reverse position than if the cone pulley were placed the same as on back-geared engine lathes. There is also less interference with the belt in doing the common run of faceplate work.

PROBLEM IN TRIGONOMETRY

I. W.—Referring to the illustration, *ACB* is a right triangle, right-angled at *C*. Please show how to find the angle *B* from the dimensions given.

A.—It is first necessary to find the length of *BE* or *AF*; with *BE* known, the angle can be found from its tangent or cosine, and if *AF* is known, the angle can be found from its sine. Let $BE = c$ and $AF = a$; then from geometry, since the triangles *BED* and *DFA* are similar, $a:3 = 1:c$, or $a = \frac{3}{c}$. Also, $(c + 1)^2 + (a + 3)^2 = 10^2$. Expanding this expression we get: $c^2 + 2c + 1 + a^2 + 6a + 9 = 100$, or $c^2 + 2c + a^2 + 6a = 90$. Substituting the value of a, gives: $c^2 + 2c + \left(\frac{3}{c}\right)^2 + 6 \times \left(\frac{3}{c}\right) = 90$. Clearing of fractions and combining terms, $c^4 + 2c^3 - 90c^2 + 18c + 9 = 0$. Solving this equation, preferably by Horner's method, $c = 8.41994$. Therefore, $c + 1 = 9.41994$, and $\cos B = 9.41994 \div 10 = 0.941994$. From a table of natural trigonometric functions, $B = 19$ degrees, 36 minutes, 39 seconds. To prove that the value of c is correct as calculated, $a = \frac{3}{c} = \frac{3}{8.41994} = 0.356297$; $a + 3 = 3.35630$, to six significant figures; $c + 1 = 9.41994$; and $9.41994^2 + 3.35630^2 = 100.0000$. J. J.

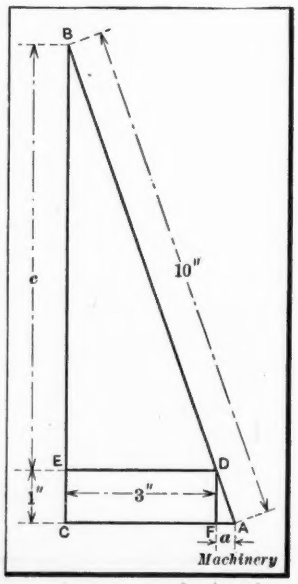
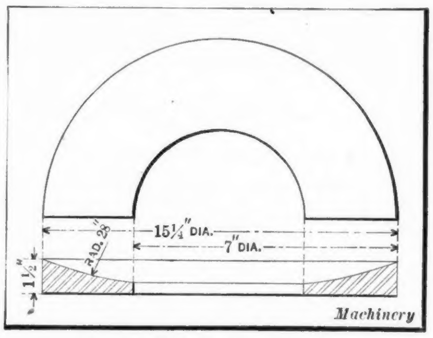


Diagram illustrating Method of finding Angle B in a Right-angle Triangle

TO HARDEN AN ANNULAR DISK WITHOUT WARPING

E. P. F. & M. Co.—We send you a sketch of a steel disk of which we have a number to make, and ask for suggestions as to the method of hardening so that they will not warp beyond reasonable limits for grinding. We machine the disks to within about 1/16 inch of the size shown in the sketch. They are then hardened and ground to finish size. We have had some trouble from warping during the hardening process, and would appreciate advice as to how the trouble can be avoided.



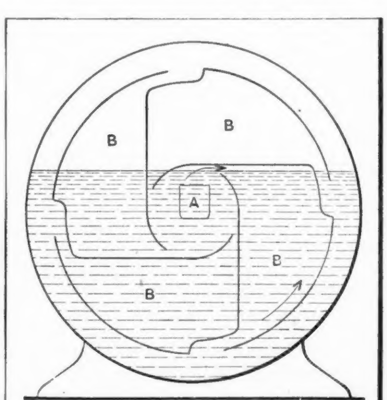
Annular Disk to be hardened

A.—The ring is of a specially difficult shape to harden without warping, because it is so much thicker at the periphery than at the inner edge of the hole, and also because the cross-section is not symmetrical with reference to a center line. Hence, the overhang when heated and chilled tends to contract and force the ring into a conical shape. You might employ the method used by makers of circular saws for holding the disk from warping when hardening. Saws are hardened between perforated circular disks, between which the saw is firmly clamped as it is immersed. Another method that might be used with success, provided the hardener is skillful, is to mount the ring on a revolving mandrel so that about one-half the width of the solid portion is immersed in the cooling bath. The ring should be revolved quickly and immersed all over as it revolves. The object is to cool the exterior first, because of the greater mass of metal, and thus to obtain simultaneous cooling throughout, with little or no tendency to change shape. This condition might also be accomplished by providing a shield of sheet metal to cover the inner part of the ring on both sides to about one-half its width. The shield should be scalloped on both edges so as to permit the water to reach the hot metal beneath, but not as freely as it would without the shield.

VOLUME OF GAS SPACE IN WET GAS METER

J. W.—I should like a formula for calculating the gas space for different heights of water level in a gas meter similar to that shown in the illustration.

A.—It is impossible to give a formula for this purpose, as you have not given sufficient information regarding the interior conditions—the shape of the ends, the shape of the blades *B*, etc. Even if this had been furnished, it is doubtful if a formula could be derived that would be of practical value. It would seem best to make a special calculation for every case; or, better still, to fill the drum with water, using for the purpose either an actual meter or a model of it, and then let the water flow out of holes drilled in one end at the desired heights. (These holes should be drilled and plugged before the drum is filled with water.) After it is filled, remove the top plug and weigh the water that flows out; this weight multiplied by 360/13 will give the volume of space, in cubic inches, occupied by the water. Then remove the second plug and repeat the calculation; the sum of the two calculations will be the volume above the second plug. In this way it is possible to obtain the volume for any desired height. J. J.

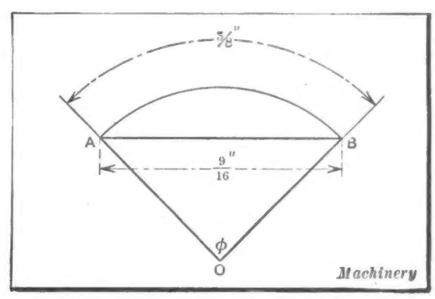


Sectional View of Wet Gas Meter

GIVEN THE CHORD AND ARC TO FIND THE RADIUS

G. H. C.—If the length of a given circular arc is 5/8 inch and the length of the chord is 9/16 inch, how can I find the radius?

A.—The easiest way to solve a problem of this kind is first to find an approximate value for the central angle $AOB = \phi$ (see illustration), then assume several other angles in that neighborhood, and, finally, calculate ϕ by interpolation. Represent the length of the arc by L and the length of the chord by C; then, for the present case, $C \div L = 9/16 \div 5/8 = 0.9$, and $C = 0.9L$. The table on pages 62 and 63 of MACHINERY'S HANDBOOK gives the length of arc and the length of chord (both to a radius 1) from 1 degree to 180 degrees. Multiplying the value of L for different angles by 0.9 until the product is equal to the value of C for that angle or very nearly equal to it, we find that for $\phi = 90$ degrees, $0.9L = 0.9 \times 1.571 = 1.4139$, and $C = 1.414$. As these two values are practically equal, ϕ is very nearly equal to 90 degrees. The radius r evidently equals $\dfrac{1/2 \times 9/16}{\sin 1/2\,\phi} = 0.3977$. It would not be safe to rely on this value of r to more than three significant figures; hence, if a more accurate value is desired, proceed as given in the following. It is first necessary to use a more accurate table. Using a six-place table, calculate L, C, and $C \div L$ for 90 degrees, 91 degrees, and 92 degrees ($C = 2 \sin 1/2\,\phi$), and then arrange in a table as here shown.



To find Radius when Chord and Arc are given

ϕ Deg.	L	C	C ÷ L
90	1.57080	1.41421	0.900312
91	1.58825	1.42650	0.898158
92	1.60570	1.43868	0.895983

Now using second differences, and applying Newton's formula for interpolation, we find that for $C/L = 0.900000$, $\phi = 90.1455$ degrees = 90 degrees, 8 minutes, 44 seconds. For this angle, $L = 1.57334 = \phi$ radians, $C = 1.41601$, and $0.9 \times L = 1.416006 = C$. Hence, $r = 0.28125 \div \sin 1/2\,\phi = 0.28125 \div \sin 45$ degrees, 4 minutes, 22 seconds = 0.397243 inch. Note that $L = r\phi = 0.397243 \times 1.57334 = 0.624998$. J. J.

FOOD VALUES IN CALORIES

J. W. Q.—A short time ago, a test was conducted whereby twelve policemen were fed three meals a day for twenty-five cents each, and it was stated that the food value was about 3000 calories per man per day. What is a calorie and what relation does it bear to the food value?

A.—The calorie is a heat unit and was originally defined as the amount of heat required to raise the temperature of 1 kilogram of water 1 degree C.; this is now called the kilogram-calorie or large calorie, and is the unit used in thermodynamic calculations. The range of temperature is now frequently taken from 17 degrees C. to 18 degrees C., under which conditions, 1 kilogram-calorie is equivalent to about 426.65 meter-kilograms or 3086 foot-pounds. This unit, however, is too large for use by chemists and others who deal in small quantities, and they have therefore adopted what is called the gram-calorie or small calorie, which is 1/1000 of the kilogram-calorie. Consequently, 1 gram-calorie = 3.086 foot-pounds of work or energy. To determine the number of calories in any particular article of food, the food is heated until all the water is driven out; the dried part that remains

is weighed and completely burned in a suitable apparatus (called a calorimeter) containing a known weight of water, and the rise in temperature of the water is noted. From these data, the calorific value of the material is obtained. Now, when food is eaten, the digestive process really produces the same effects as slow combustion, and thus generates heat, the amount generated being exactly the same as when the material is burned. This heat performs several functions in connection with animal life: it keeps the body temperature constant, and it furnishes the energy necessary for breathing, movement, exercise, work, etc. If more food is eaten than is required to produce these effects, the surplus energy is stored in the body in the form of fat and the weight increases; but if less food is eaten than the body demands, it draws first on the fat to supply the extra energy, and when this is gone, it consumes the lean and other tissues, and the weight decreases. A full-grown, normal man, under ordinary conditions, requires about 3000 calories per day in order neither to gain nor lose in weight, and perform his daily work. J. J.

EFFICIENCY OF MACHINES

R. A. F.—Will you please explain what is meant by the word "efficiency" when applied to machines?

A.—Speaking in general terms, the efficiency of a machine may be defined as the ratio of the work delivered by the machine to the work supplied to it. For instance, if 75 foot-pounds of work or energy are supplied to a machine and the machine can deliver only 60 foot-pounds of useful work, the machine is said to have an efficiency of $60 \div 75 = 0.80$, or 80 per cent. It frequently happens, however, that the work will be proportional to a force or some other quantity, in which case the efficiency may be measured by a comparison of two forces or other quantities. For instance, referring to the illustration, let P be a force acting on one end of a rope that passes over a pulley and has a weight Q attached to the other end. If P moves through a distance p, Q will move through a distance q, and, by the principle of virtual velocities, $Pp = Qq$, when it is assumed that there are no wasteful resistances, such as friction of the bearings, bending of the rope, etc. The efficiency in this case would evidently be 1, or 100 per cent. Since, however, there are wasteful resistances, they may be represented by W and the distance through which they act by w; consequently, the foregoing expression becomes $Pp - Ww = Qq$, or $Pp = Qq + Ww$, and the expression for efficiency becomes $\frac{Pp}{Qq + Ww}$. Since every machine or part of a machine offers wasteful resistances, the efficiency must always be less than 100 per cent, *i. e.*, it must always be a fraction less than unity. Referring again to the illustration, let P_0 be the force required to move the load Q when wasteful resistances are neglected, and let P be the force actually required to move the load; then the efficiency may be defined as $e = \frac{P_0}{P}$, in which e is the efficiency. If a machine is made up of a number of separate parts, the efficiency of the entire machine is the product of the efficiencies of the several parts, *i. e.*, $e = e_1 \times e_2 \times e_3$, etc. In the case of any heat engine, the energy of the working fluid (gas, air, steam, etc.) is proportional to the temperature; hence, if T_1 is the temperature of the fluid as it enters and T_2 the temperature on leaving (both absolute), the thermal efficiency is $T_1 - T_2 \div T_1$. J. J.

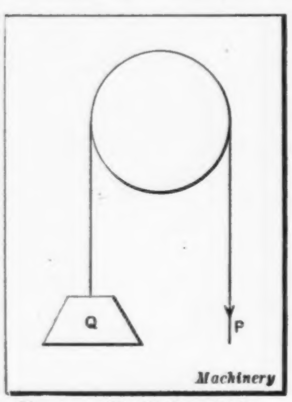


Diagram illustrating Determination of Efficiency of Machines

FINDING THE ANGLES OF A TRIANGLE

A. F. O.—I recently had to lay out a triangular piece, the lengths of the sides of which were 1 5/16 inch, 3 1/4 inches, and 3 11/16 inches; later I desired to know the angles, but could not measure them accurately enough with a protractor. Please show me how to calculate the angles.

A.—There are a number of formulas for calculating the angles, one of which is given on page 153 of MACHINERY'S HANDBOOK. This formula may be put into an easier form for calculating by a slight rearrangement and factoring of the terms, thus: $\cos A = \frac{b^2 + c^2 - a^2}{2bc} = \frac{1}{2b}\left[c + \frac{(b+a)(b-a)}{c}\right]$; also $\cos B = \frac{1}{2a}\left[c - \frac{(b+a)(b-a)}{c}\right]$. In these two formulas, a is the shortest side and c the longest side. Referring to the figure, it will be noticed that the angles A, B, and C are opposite the sides a, b, and c, respectively. The chief advantage of these two formulas is that having calculated the fraction by one formula, the result can be substituted in the second formula; also, it is not necessary to square three different numbers. In the present case, $a = 1\,5/16 = 1.3125$, $b = 3\,1/4 = 3.25$, and $c = 3\,11/16 = 3.6875$; therefore,

$$\cos A = \frac{1}{2 \times 3.25}\left[3.6875 + \frac{(3.25 + 1.3125)(3.25 - 1.3125)}{3.6875}\right]$$

$= \frac{1}{6.5}(3.6875 + 2.39725) = 0.93611$. The angle the cosine of which is 0.93611 is 20 degrees, 35 minutes, 30 seconds. Again substituting, $\cos B = \frac{1}{2 \times 1.3125}(3.6875 - 2.39725) = 0.49153$ = cos 60 degrees, 33 minutes, 31 seconds. Angle C = 180 degrees − (20 degrees, 35 minutes, 30 seconds + 60 degrees, 33 minutes, 31 seconds) = 98 degrees, 50 minutes, 59 seconds. J. J.

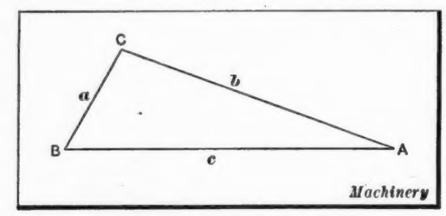
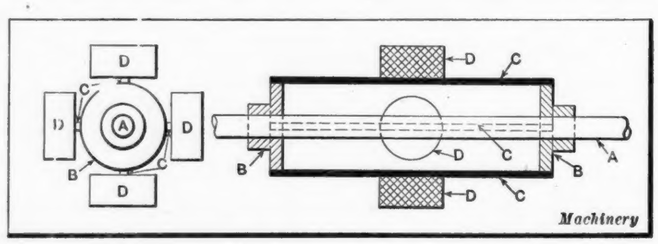


Diagram illustrating Method of finding Angles of a Triangle

GOVERNOR FOR REGULATING SPEED OF VICTROLA

F. H. G.—The illustration shows a sectional view and plan of a governor for a victrola. The sleeves B slide up and down the splined shaft A and are connected to each other by four flat springs C that carry lead weights D in the middle. As the weights revolve, the centrifugal force throws them out against the resistance of the springs (and gravity) and brings the sleeves closer together, causing them to move a lever operating a friction device that reduces the speed. I should like a formula fitting this type of governor.

A.—We know of no formula that will apply to a case of this kind, and we doubt very much the possibility of deriving one that would be of any practical value. It is the opinion of the writer that the results to be obtained with a device like this could only be determined by direct experiment. The curve of flexure of the springs will be similar to that of a beam fixed at both ends, and it will be further modified by the character of the lead weights; that is, by their size and shape. If a number of such governors were to be constructed, and of different sizes, it is probable that an empirical formula could be derived that would give results sufficiently accurate for practical purposes. J. J.



Sectional and Plan Views of Victrola Governor

* * *

Japan has supplanted Germany in furnishing electric-light bulbs to Russia and the cheaper electrical devices to China.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

JORDAN AUTOMATIC PROFILE SHAPER

The design of this machine has been so worked out that a die is completely finished without requiring subsequent hand work. Furthermore, the method of operating is so simple that it may be safely entrusted to a boy of average intelligence. In starting to make a die, a templet of the required outline is made from 1/8-inch sheet steel, and if this templet is to be used repeatedly, it is casehardened around the edge of the opening. When the templet is of no further use, it may be employed as a stripper plate. If a number of dies of the same outline are required, it is often practicable to produce several dies at the same time.

A number of machines have been developed to facilitate the making of blanking dies, the idea being not only to save on the high wages paid to toolmakers and diemakers, but also to produce work of the highest quality. Most of these machines have to be operated by hand, and it is generally necessary to employ an experienced toolmaker for this class of work; the contour of the die must also be laid out by hand, no matter how many of one set of dies are required, and after the die leaves the machine it has to be finished by hand. An interesting addition to the group of machines for handling work of this kind has recently been developed by the Luster-Jordan Co., Inc., Franklin Ave. and Washington St., Norristown, Pa. This machine is almost fully automatic, and is said to produce a die which is accurate in every respect, the edge being as clean as that of a hand-made die, and the taper perfect all the way around the die opening. Provision may be made for obtaining any desired taper, and there is no danger of spoiling the die, no matter how long the machine runs without attention from the operator. The control of the machine is so simple that it is claimed that any boy of average intelligence can operate it and obtain results equal to those produced by a high-grade toolmaker working by hand; furthermore, the time required to finish the dies is usually from one-tenth to one-twentieth of that required to do the work by hand, and if a number of dies of the same outline are required, it is possible to make two or three dies at one setting.

This machine is adapted for an extremely wide range of work and is substantially constructed to stand up under severe conditions of service. Its most important feature is the universal table, which is best illustrated in Fig. 4. Probably the best way to explain the operation of this machine is to describe the steps taken in making a die. First it is necessary for an exact templet of the die to be made, 1/8-inch sheet steel being used for this purpose; this is hardened around the opening if the templet is to be used repeatedly. For this purpose cyanide hardening will be found satisfactory. No matter how simple or how complicated the die may be, or whether one or more dies of the same shape have to be made, it is claimed that it is always easier to make a templet from steel 1/8 inch in thickness than to lay out a die and cut it by hand, because this machine completely finishes the die and can be operated by non-skilled labor. After cutting the die, the templet may be used as a stripper plate if it is of no further use. When the templet has been made, the die should be roughed out as far as possible, although this is not absolutely necessary so long as one hole can be made through which to pass the tool. The die is placed on the machine, and if it happens that the die is smaller than the hole in the table, a pair of parallels is placed underneath it; then the templet is put in position on top of the die with a space of about 1/4 inch between the templet and the die. This space serves as a clearance for the

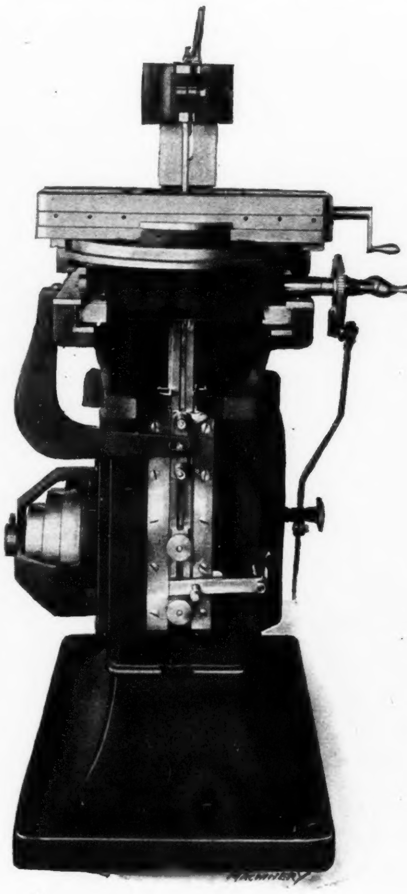


Fig. 1. Front of Automatic Profile Shaper

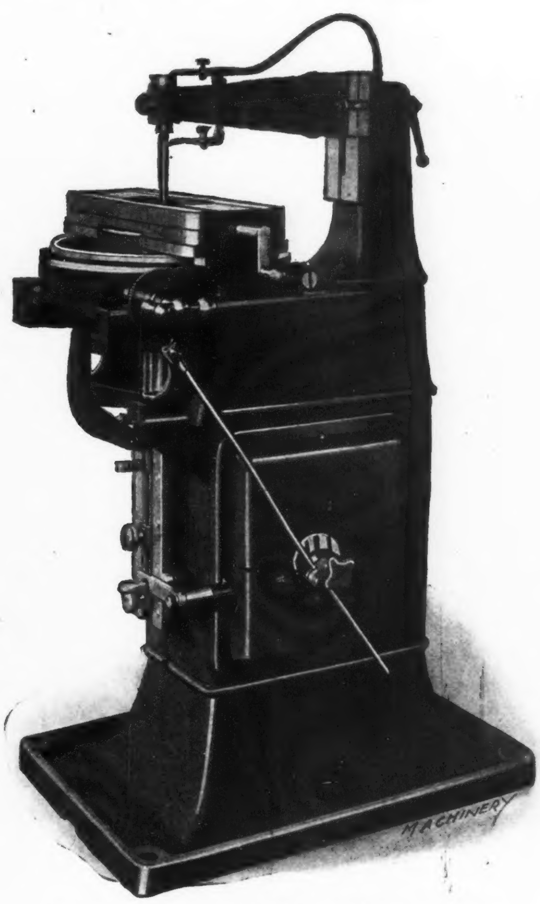


Fig. 2. Side View of Machine, showing Arrangement of Universal Table and Tool

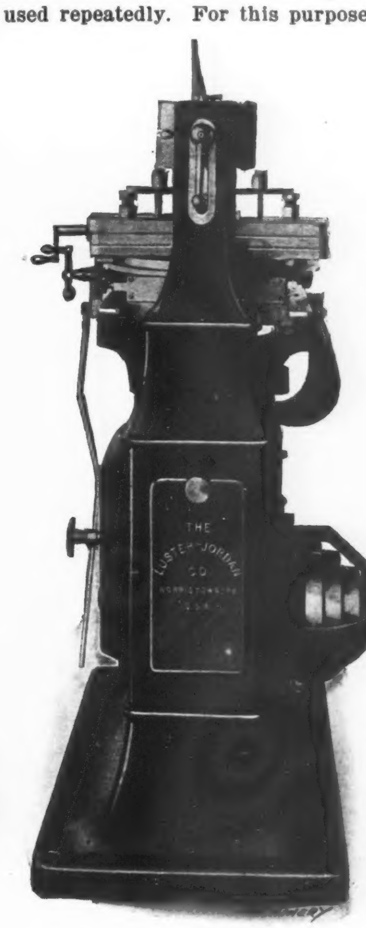


Fig. 3. Back of Machine, showing Drive, etc.

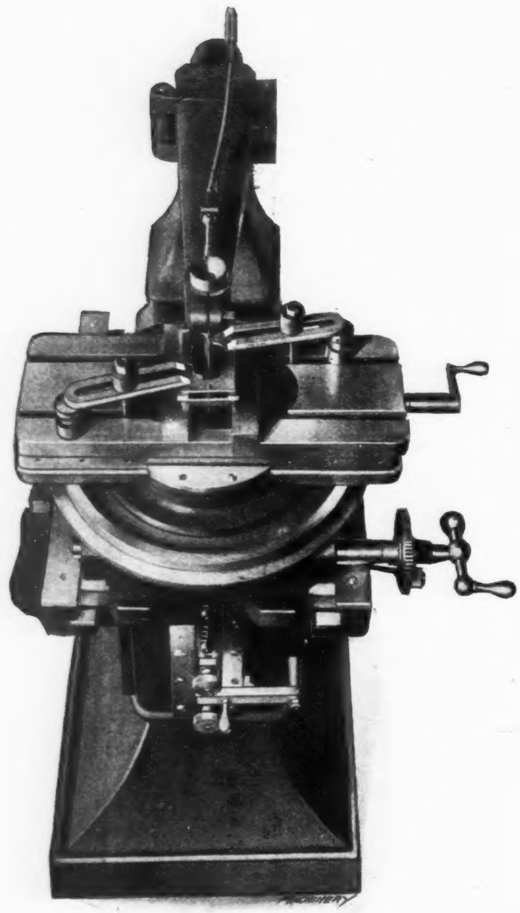


Fig. 4. View looking down on Machine, which shows Construction of Universal Table

tool, and the die and templet are held by two clamps which are adjustable for varying thicknesses of the die.

The tools used on this machine are generally made from a piece of drill rod, which is milled in the center to a triangular form with the cutting edge obtained by recessing the lower part of the tool; for instance, if it is required to cut 1/8 inch at a time, the tool is recessed 1/8 inch. The tool is inserted in the ram of the machine and guided from above by the supporting arm. Lubrication is obtained by a geared pump, which not only supplies the tool with lubricant, but also takes care of the entire lubrication of the machine. Adjustment of the length of stroke may be obtained, so that at the highest position of the ram, the cutting edge of the tool is in the space between the die and templet. It will be apparent that the tool works up and down as on a vertical shaper, and transverse, longitudinal and rotary motions of the table are available for feeding the work to the tool. The cutting action of the tool continues until the upper part strikes the templet, this portion of the tool serving as a guide. From this it will be apparent that the tool can never cut below the "finishing line" on the die, *i. e.*, it is practically impossible to spoil the die. Two locks on the ram make it an easy matter to adjust the stroke from the front of the machine.

Three self-aligning roller bearings provide for easy sliding of the table on the bed of the machine, and provision is made for counterbalancing the table under different conditions, the counterweights being applied in such a way that they press the work carried on the table toward the tool. At the end of every up stroke of the tool, the table is automatically locked and remains locked while the tool takes its cut. This is effected by a brake shoe on the upper part of the ram. Upon the completion of the up stroke, this brake shoe, by means of friction, moves an eccentric lever which presses the gib of the table into such firm contact that the table is secured against movement. When the down stroke has been completed, *i. e.*, after the cutting has been finished, the ram automatically releases the brake shoe so that the table may slide back for the next cut. In order to facilitate removal of the tool, the upper supporting arm swings on a hinge. It will be seen that the main drive of the machine is by a two-step cone pulley which is furnished with a friction clutch and accelerates the return of the tool.

The regular equipment furnished with this machine includes two clamps and adjusting locks, three cutting tools of various diameters, and one complete set of wrenches for making all adjustments on the machine. In this connection it may be mentioned that cutting tools are furnished in sizes ranging from 1/8 to 1 inch, inclusive, by intervals of 1/8 inch. Special tools and tool-holders equipped with ordinary tool bits may be furnished as extra equipment for slotting and keyseating operations, and a file-holder on the ram may also be supplied as extra equipment. The principal dimensions of the machine are as follows: capacity for circular work, up to 8 inches in diameter; capacity for oval work, up to 12 by 6 inches in size; size of table, 22 by 8 inches; distance from center of cutter to supporting arm, 16 1/2 inches; stroke of ram, 1/4 to 6 inches; speed of countershaft, 225 R. P. M.; power required to drive the machine, 2 horsepower; range of cutting speed, 20 to 35 feet per minute; dimensions of cone pulley steps, 8 and 10 1/2 inches in diameter by 2 inches face width; over-all height of machine, 58 inches; distance from floor to table, 48 inches; and floor space occupied, 28 by 38 inches.

MEDINA DRILLING AND SPACING MACHINES

In general respects, the design of this heavy-duty drilling and boring machine follows standard practice in the construction of tools of this type. The same is true of the universal spacing machine with the exception of the table and the provision of a vernier adapter for making accurate settings of the work preparatory to boring holes. By means of this adapter, which is described in detail, settings can be made accurate to 0.00001 inch.

The illustrations presented in connection with the following description show a heavy-duty drilling and boring machine, and what is styled a "universal spacing machine," which are products of the Medina Machine Co., State Rd., Medina, Ohio. It will be apparent that the design of the two machines is the same, with the exception of the base and table, which have been modified as shown in Fig. 2 to adapt the spacing machine for performing those classes of precision boring for which it

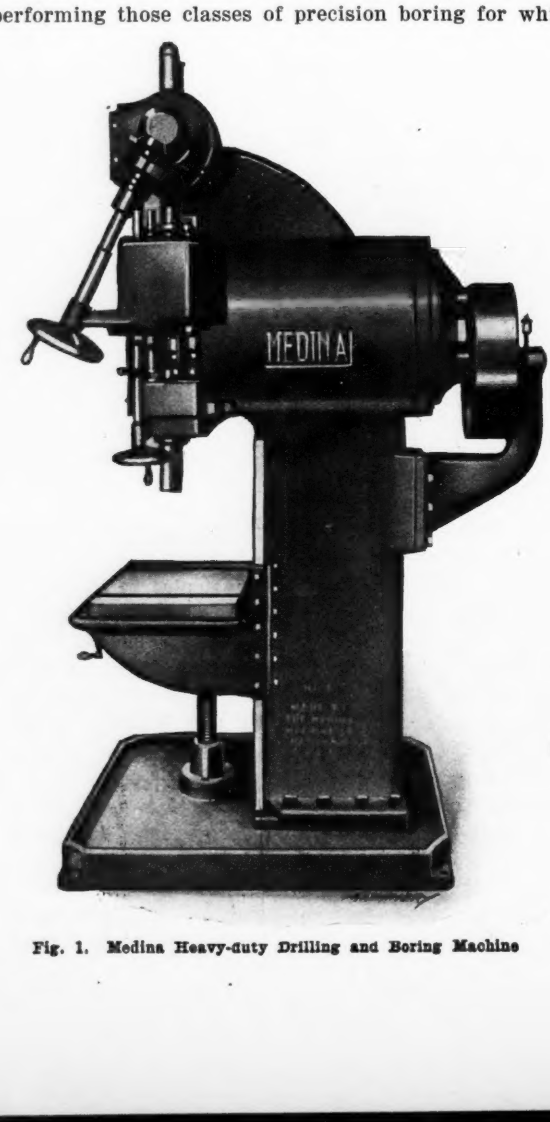


Fig. 1. Medina Heavy-duty Drilling and Boring Machine

is intended. A general description of the drilling and boring machine will be presented, and this will apply also to the spacing machine, with the exception of features of design of the table, which will be described in detail.

Heavy-duty Drilling and Boring Machine

This machine has been especially developed to meet the requirements of heavy-duty work, and the bed is well ribbed throughout to adapt it for severe conditions of service. On heavy work, lubrication is of exceptional importance, and to provide for continuous circulation of cutting compound, a reservoir is provided in the base to receive the fluid which is first drained through a screen to remove chips and dirt. The column is of heavy box construction, and the ways are planed up far enough to provide for mounting special heads for multiple-spindle drilling. In working out the design, care has been taken to make the machine of simple construction and easy to operate. All control levers are placed within easy reach of the operator when standing at the front of the machine, and all gears are guarded to comply with the safety laws in various states.

The spindle is so designed that perfect alignment and adjustment may be maintained without the bearings tending to bind or become heated. The driving gear is mounted close to the working end of the spindle, so that torsional strains are practically eliminated. As the machine is intended for heavy work, provision of means for taking the spindle thrust is a matter of importance, and such means are provided by an S. K. F. ball thrust bearing. The spindle and spindle sleeve are of forged crucible steel, accurately ground for the entire length; the spindle slides through the sleeve, and only the sleeve runs in bearings. There is a conical shaped journal at the lower end of the spindle sleeve; the upper end is straight and has a close fitting conical sleeve that extends over the spindle sleeve proper, and is driven simultaneously with it by means of a key.

This arrangement provides for variation of the spindle sleeves through expansion, and has no effect upon the conical bearings, although the spindle and sleeves are maintained in perfect alignment. The spindle head is rigidly fastened to the column and is self-contained in a unit with the spindle,

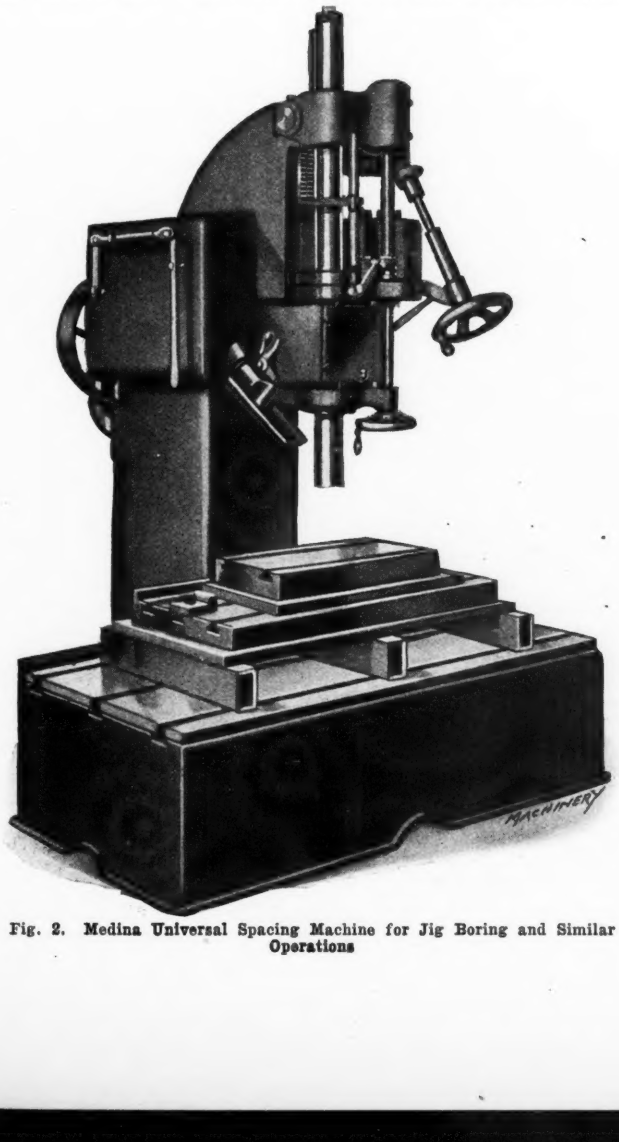


Fig. 2. Medina Universal Spacing Machine for Jig Boring and Similar Operations

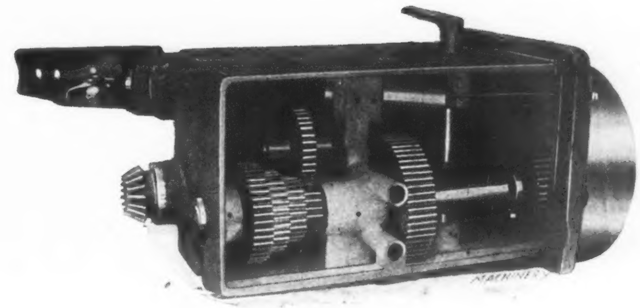


Fig. 3. Type of Gear-box used on Both Spacing and Drilling Machines

driving gear, and feed works. This head contains a housing for the driving bevel gear and feed worm and worm-wheel, so that these members run in grease. The spindle drive is direct from the bevel pinion of the geared speed-box to a large driving bevel gear mounted on the spindle sleeve, which drives the spindle through the sleeve with two steel keys of special design, the arrangement being such that there is no torque in the driving sleeve. The spindle is driven at its point of largest diameter, and as previously mentioned, the driving gear is placed close to the work.

Starting and stopping the machine is effected by a powerful Johnson friction clutch, which is easily adjusted without disturbing any other parts. A tight fitting cover closes the speed-box, which is oil-tight to enable the driving gears to run in oil, and this also provides thorough lubrication for the Hyatt roller bearings which are used. The box contains nine machine steel hardened change-gears and four semi-steel wide-faced gears that operate from the clutch. Only two idle gears are in mesh when the machine is in operation. Speed changes are made by a roll-in gear. Whether the machine is driven by belt or motor, the drive may be constant speed, variations being obtained by the gears in the speed-box. When motor drive is employed, the motor can be mounted on a bracket at the rear of the machine, and if a variable-speed motor is employed, speed changes may be obtained from the motor, no speed-box being used. In single-purpose manufacturing the speed-box can sometimes be eliminated and a single-speed drive or a three-step cone pulley and countershaft made to give the desired service. The gear-box is aligned with the spindle center by a boss turned on the front end of the box, which fits into a bore in the head which provides for obtaining proper alignment.

Changes of feed are obtained through a feed-box with semi-steel gears and a slip key that provides for engaging the particular pair of gears that are required. Bearings in the feed-box are bored and bronze-bushed, so that accurate alignment is maintained, and one feed gear is provided with a safety friction which prevents danger of stripping the teeth. An automatic knock-out is provided to disengage the feed clutch at any desired point, and handwheels within easy reach of the operator provide for obtaining hand feed and quick return to the spindle. The table is of plain box section, strongly ribbed, and has a channel extending around the edge to carry away cutting compound. Heavy straps are provided to secure the table to the column and maintain the required alignment. The table is raised and lowered by telescopic jack-screws, so that it is not necessary to cut a hole through the floor to provide clearance for the lower end of the screw.

The principal dimensions of the machine are as follows: diameter of spindle, 3½ inches; Morse taper in spindle, No. 5; maximum spindle traverse, 14 inches; maximum distance from spindle to table, 32 inches; distance from center of spindle to face of column above knee, 12 inches; working size of plain table, 19 by 20 inches; maximum lift of table, 16¾ inches; range of eight spindle speeds as follows, 54, 85, 108, 132, 170, 207, 265 and 414 revolutions per minute; range of four available power feeds as follows, 0.006, 0.011, 0.016 and 0.032 inch per spindle revolution; size of driving pulley, 20 inches in diameter by 5 inches face width; recommended speed for driving pulley, 400 revolutions per minute; power required to drive machine, 10 horsepower; capacity, up to 3-inch high-

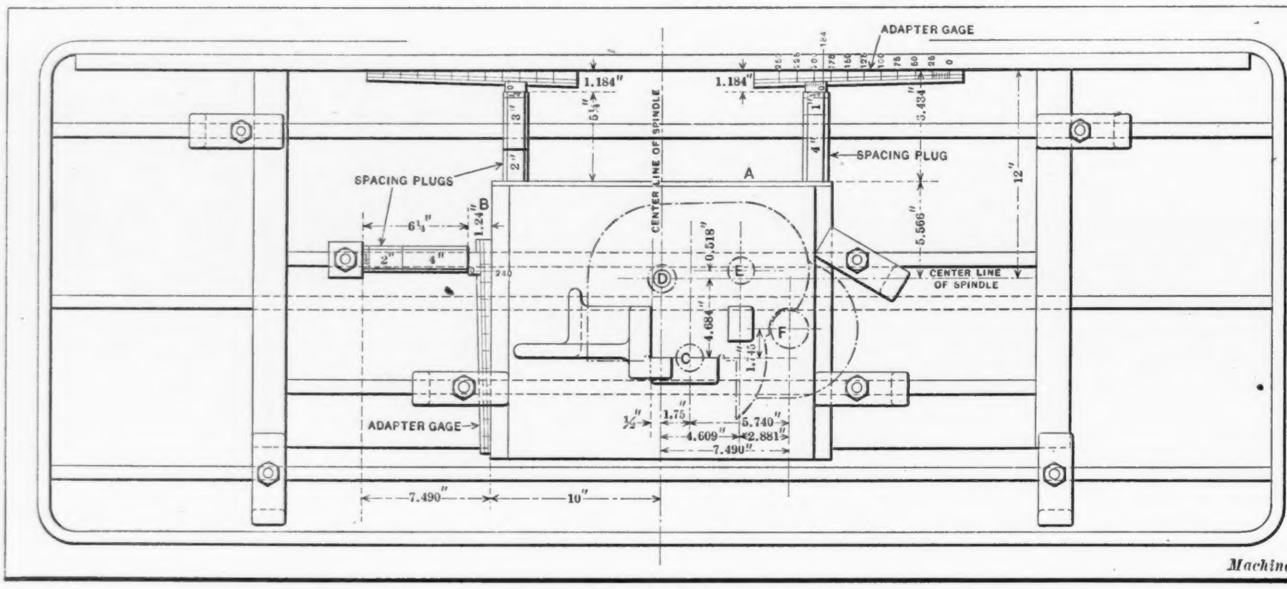


Fig. 4. General View of Table, showing Method of using Vernier Adapter to get Settings Accurate to 0.00001 Inch

speed drills; maximum over-all height of machine, 9 feet, 3 inches; floor space occupied, 34 by 65 inches; and weight of machine, 5000 pounds.

Universal Spacing Machine

To meet the requirements of jig boring and similar operations, the Medina Machine Co. has developed a machine known as a universal spacing machine, which is shown in Fig. 2. In addition, the machine is suitable for manufacturing work where it is required to bore holes to close limits without the use of jigs. This is done through the use of set-blocks and an adapter gage, which make it possible to space holes within 0.00001 inch. It will be seen that the base of the machine is provided with three T-slots running lengthwise to provide for clamping jigs, angle-plates, or other work-holding devices. This base is provided with a planed strip at the rear, which runs the entire length of the base and is used in connection with hardened blocks, against which the gage blocks may be set. This strip is made accurate for square and straight, so that it constitutes a reliable reference point. The platen is also provided with three T-slots for holding work or clamping down a small auxiliary table. This platen is provided with finished edges which are planed square and provided with hardened strips, as in the case of the base. Clamp strips are provided at the ends and sides for clamping down work in the desired position. The smaller or auxiliary platen is used in connection with either the base or main platen of the machine, according to the requirements of the work. As will be seen, two T-slots are provided for securing the work in place. In many cases it is desirable to set up the large platen on parallels, as shown in the illustration.

A gage block end stop with a hardened steel face is provided to fit in the center slot of the base or large platen. Clamp bolts hold the stop in any desired position. Gage blocks are provided in sets of three, which are made of tool steel, hardened, ground and lapped, two ends and one flat being square and the ends parallel to each other. These blocks are made in the following lengths: 0.250, 0.5, 0.750, 1, 2, 3 and 4 inches. They are of approximately this length, any variation under or over this amount being etched in the block and expressed as decimals carried out to the fifth place, so that they are correct to 0.00001 inch. These blocks are used in connection with an adapter gage and also with Johansson blocks when so desired. This adapter gage is furnished with a tapered strip of non-shrinkable steel, which is hardened, ground and lapped. The taper is 0.250 inch in twenty-five centimeters, so that each millimeter space represents 0.001 inch. The vernier splits one millimeter into fifty spaces, making each vernier space equivalent to 0.00002 inch, and by estimating half spaces settings are made to 0.00001 inch. This degree of accuracy may be obtained in making settings, but in practice there are other limitations that prevent securing quite such precision in the spacing between holes. Three of these adapter gages are provided with gage blocks, using one on one end against the gage block end stop, and two on one side of the platen next to the machine for spacing. The scales are placed so that they are visible when the adapter rests on the platen, making two of one hand and one of another.

SAYLOR SHELL WASHING MACHINES

The line of shell washing machines developed by the Pottstown Machine Co., Pottstown, Pa., was designed with the intention of washing the shell as thoroughly inside as outside. The smaller machine shown in Fig. 1 is made to accommodate shells up to six inches. It consists of a large rectangular tank in which revolves a six-station wheel having a cradle for accommodating six shells. The construction of this wheel is similar in every respect to the well-known ferris wheel. The wheel is revolved constantly and the operator removes a shell and loads one from the two stations of the wheel that are raised out of the tank, unloading and loading being accomplished with the small crane.

The cradle in which the shell is laid is free to swivel, and it is so balanced that the tendency is to tilt the nose of the shell downward. Two of these cradles are out of the tank all the time; the one to the right is in a position for unloading while

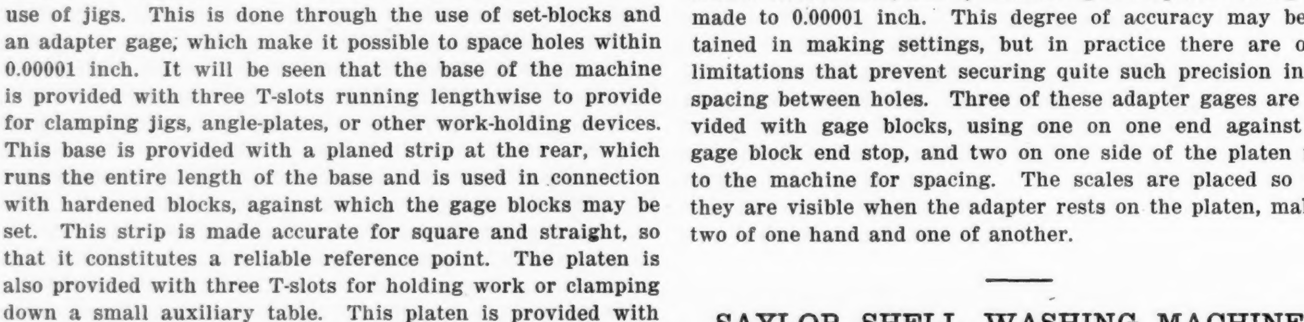


Fig. 5. Detail View of Vernier Adapter and Gage Block of Type shown in Use in Fig. 4

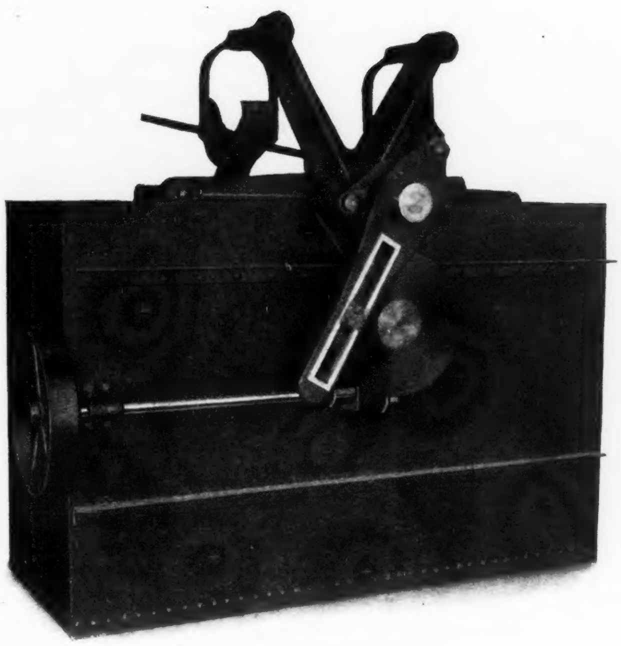


Fig. 1. Saylor Continuous Shell Washing Machine for Six-inch Shells

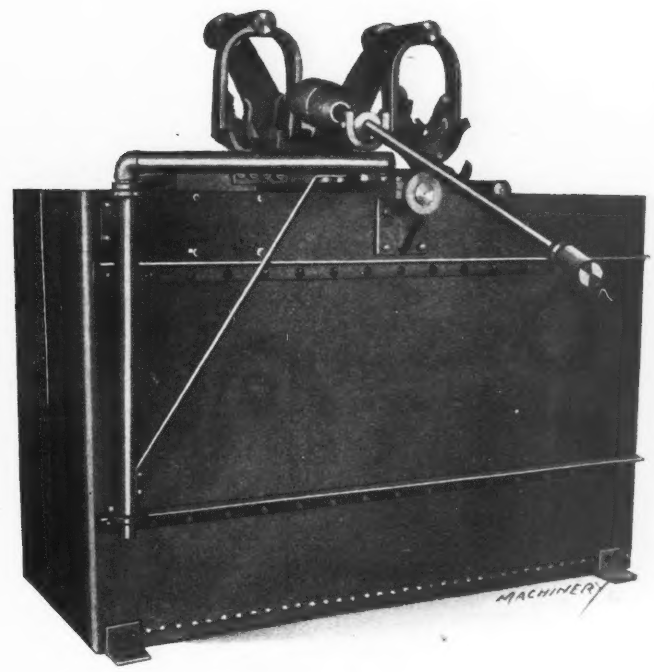


Fig. 2. Opposite Side of Saylor Shell Washing Machine shown in Fig. 1

the one to the left is in a position for loading. In the loading position, the cradle is prevented from tilting the shell nose downward by a rest on which the end of the cradle bears. The shells enter the liquid, heel downward, and are held in this position for a sufficient time to allow them to be filled with the liquid. This is effected by a barrier of sheet metal that is interposed in the path of the cradles, causing them to tilt in a backward position.

After each cradle has remained tilted with the shell nose in an upward position for a sufficient time to allow it to become filled with liquid, it breaks contact with the barrier and tilts to an angular position with the shell nose pointing downward. This causes it to line up with the nozzle of a steam pipe which blows a strong jet of steam directly into the shell, greatly agitating the liquid and causing every particle of dust, dirt, and chips to be effectively removed. The shell is then moved on to the next position, where a second jet of steam repeats the process. These two jets of steam not only clean the shell thoroughly inside, but they also agitate the entire mass of liquid and keep the temperature raised. One operator is used on this machine to load and unload the wheel, and the machine has washed as many as 2000 shells in a ten-hour day.

The shell washing machine shown in Figs. 3 and 4 is made on practically the same lines, with the exception that the motion instead of being continuous is intermittent. The ferris wheel has six positions, as in the other machine, but the machine must be tripped by the operator for every shell that is loaded, and the wheel revolves one-sixth revolution when the clutch is thrown out. The mechanism is tripped by the operator who presses a hand-lever that transmits power through the hollow shaft to a bellcrank at the back of the machine. The movement of the bellcrank is transmitted to a lever which throws the clutch into engagement, at the same time throwing the trip lever out of the path of the trip pin, of which there are six equally spaced around a disk which is integral with the main shaft and bears a fixed relation to the six arms of the ferris wheel. Aside from this one feature, this shell washing machine is essentially the same as the one previously described and takes shells up to twelve inches.

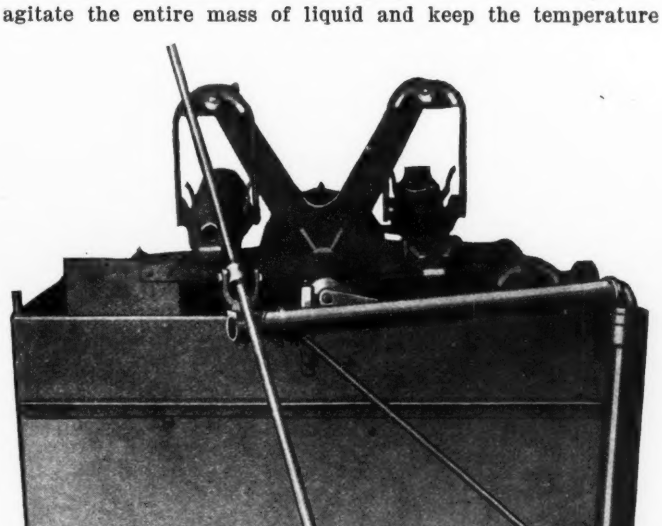


Fig. 3. Saylor Intermittent Shell Washing Machine for Twelve-inch Shells

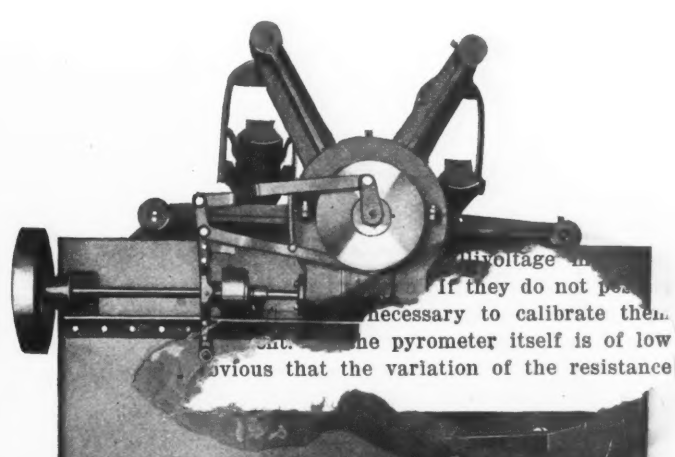


Fig. 4. Opposite Side of Saylor Shell Washing Machine shown in Fig. 3

PARKER DRILL CHUCK

To meet the requirements of high-speed drilling operations, the Parker Mfg. Co., 410 Kerr Bldg., Detroit, Mich., is now making a drill chuck that forms the subject of this description. Six sizes of this chuck are made for the requirements of general drilling operations, and six sizes for use on portable tools. The body is made of steel and extends nearly to the extreme diameter of the chuck, the purpose being to eliminate distortion under severe strains and to prevent the jaw hole or runway from breaking through the metal in the body. This permits the use of jaws of large diameter and affords a firm seat for the nut that controls the jaws in operation. If so desired, a hole can be drilled in the body to permit the use of a piece of drill rod for preventing rotation should the operator lose

Drill Chuck made by Parker Mfg. Co.

his pinion and wish to open or close the chuck by hand when in use on a portable drill or drill press. The pinion holes are equipped with hardened bushings so that the holes will not become elongated when the operator is adjusting the jaws to the required diameter.

The split nut is made of alloy steel, properly hardened and ground, and the shape of the thread is especially designed to withstand tremendous strain. By a special process of heat-treatment, the jaws are left hard on the gripping surface and threaded portion, while the metal is soft farther back to insure toughness and tensile strength; each jaw is ground all over to the correct diameter, insuring interchangeability. The ferrule is made of chrome-nickel steel and heat-treated to give the desired physical properties; the teeth are milled in such a way that when the teeth of the ferrule and pinion are in mesh the lines converge to a given point. The pinion is made of vanadium steel and is of large diameter, with the teeth cut to insure their meshing properly with the teeth on the ferrule.

SCOTT BORING-TOOL HOLDER

The C[illegible] Machine Co., Cleveland, Ohio, has recently plac[illegible]ided in se[illegible] new boring-tool holder, which is illus- [illegible]ened, ground and la[illegible]h. The method of adjusting this and the ends parallel to e [illegible] in the following lengths: 0.250, 0.5, 0.[illegible] They are of approximately this length, a[illegible]

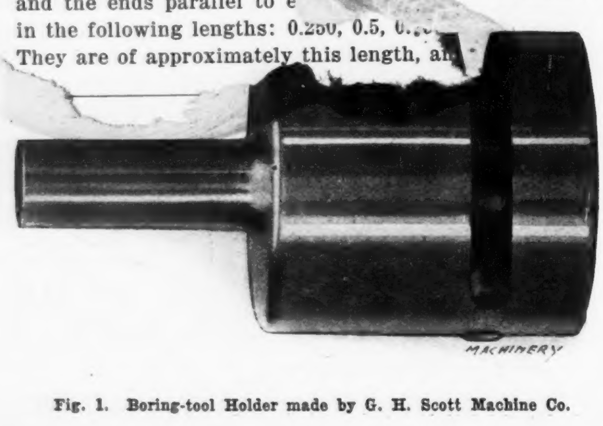


Fig. 1. Boring-tool Holder made by G. H. Scott Machine Co.

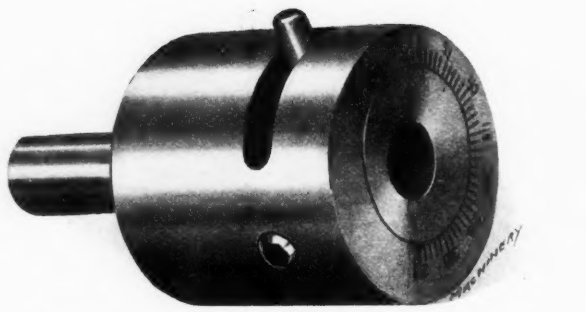
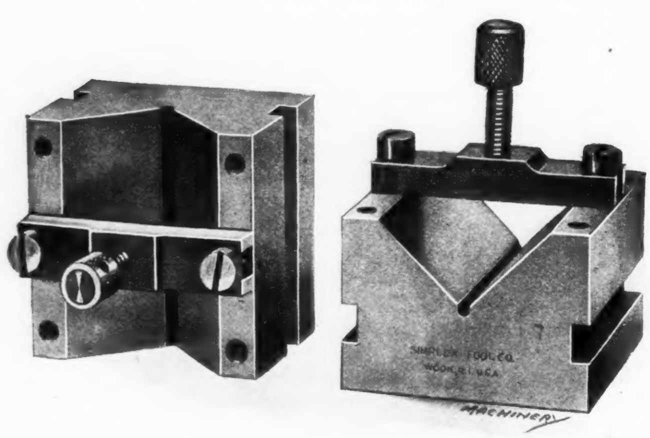


Fig. 2. Graduations on Scott Tool-holder that facilitate Setting

tool consists of offsetting both the inner and outer parts; it is possible to offset the tool up to ¼ inch by intervals of 0.001 inch. The graduations provided on the tool enable the mechanic to bore several duplicate holes without resetting his tool each time, by simply throwing the tool to the central position and then working back to the same graduation mark. The inner rotating part of the holder is made of hardened steel; the inserted tool is held in place with a safety set-screw, and the inner rotating center is securely held by another set-screw. The construction of this tool-holder insures absolute rigidity in all positions. It is furnished with a ½-inch straight shank to fit either the drill or milling machine chuck. It has a capacity for tool shanks up to 7/16 inch.

SIMPLEX V-BLOCKS

The Simplex Tool Co., Woonsocket, R. I., is now making the V-blocks illustrated and described herewith. These blocks are 2½ by 2½ by 1¾ inch in size, and are made of steel which is hardened, after which the blocks are ground on all the surfaces. Attention is called to the following features. The vee is



V-blocks made by Simplex Tool Co.

ground to a 90-degree angle and is in perfect alignment with the sides and base, at right angles to the ends, and central with the sides. The clamp is designed so that it will not interfere when the block is used on its side. Two grooves are provided in the sides for convenience in clamping, thus leaving the top clear for the work. These V-blocks are made in pairs to insure perfect alignment when used together, but they may be bought either singly or by the pair.

INTER-STATE LUBRICANT PUMPS

The Inter-State Machine Products Co., Inc., Rochester, N. Y., is now building two types of the "Sterling" circulating oil pump, which are illustrated in Figs. 1 and 2. It will be seen that these are of practically the same design except that one is provided with an automatic relief valve for controlling the maximum pressure, while the other is not. These pumps are of the geared type with which most mechanics are familiar, and are suitable for use on all classes of machine tools in which it is desired to deliver oil or cutting compound to the work. "Sterling" pumps are made to operate in one or both

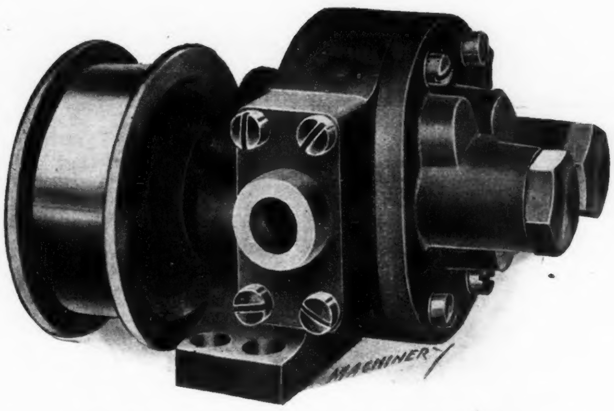


Fig. 1. Inter-State Machine Products Co.'s "Sterling" Lubricant Pump with Automatic Relief Valve

directions, and on the type provided with an automatic relief valve the operator can shut off the fluid at the point of discharge without creating pressure in the pump. It is not necessary to provide an auxiliary relief valve beneath the pump. The recommendation is made that the suction be provided with a strainer, and it is also an advantage to place the pump as near the level of the fluid as possible. The principal dimensions are as follows: diameter of inlet, ⅜ inch; diameter of outlet, ⅜ inch; size of driving pulley, 3½ inches in diameter by 1⅛ inch face width; capacity, 1¾ gallon at 300 R.P.M.; 2¼ gallons at 400 R.P.M., and 2¾ gallons at 500 R.P.M.; and weight of pump, 11 pounds.

"BELTOL"

E. R. Senn & Co., 405 Lexington Ave., New York City, are now manufacturing a compounded oil known as "Beltol." This oil is applied to leather belting for the purpose of bringing out those physical properties which will enable advantage to

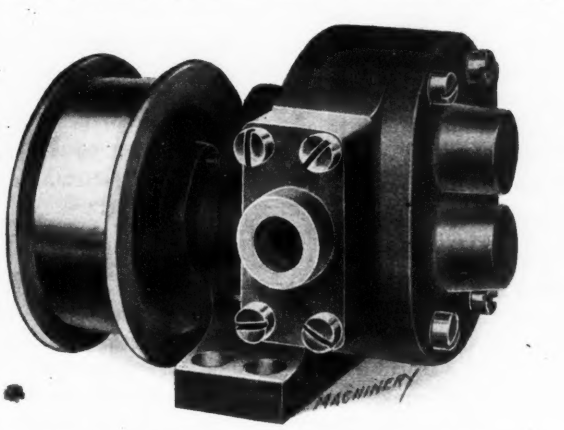


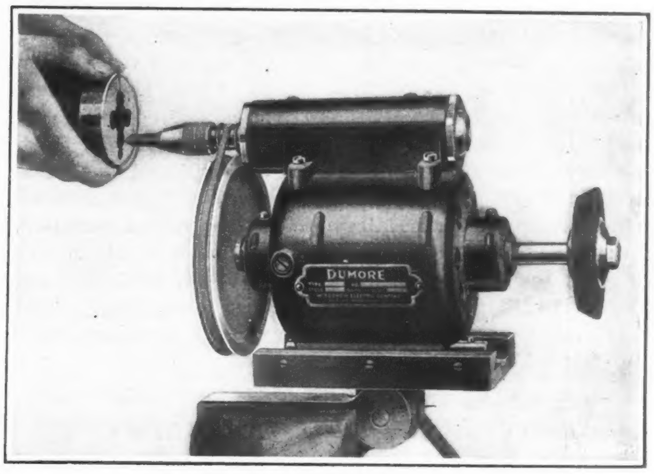
Fig. 2. Inter-State Machine Products Co.'s "Sterling" Lubricant Pump without Automatic Relief Valve

be taken of the maximum efficiency in power transmission. The oil is applied from a small container and is poured slowly onto the inside of the belt half way between the two pulleys while the belt is in motion. It is recommended that application of "Beltol" be made once every seven days, and the claim is made that this treatment will result in an increase of efficiency in power transmission ranging from 3 to 28 per cent, according to the original condition of the belting. "Beltol" was developed in 1899 by the French chemist M. Du Puis, and is being manufactured in England and France as well as in America.

HIGH-SPEED "DUMORE" GRINDER

In the April, 1914, number of MACHINERY, an illustrated description was published of the "Dumore" grinder made by the Wisconsin Electric Co., 1402 Dumore Bldg., Racine, Wis. This machine was designed for operation at 30,000 revolutions per minute. To meet the requirements of shops turning out large quantities of automatic screw machine products, where difficulty has been experienced in keeping button dies in condition for operation at maximum efficiency, a grinder known as a "high-speed equipment C" has recently been placed on the market by the same company. The motor is of the same design as that on the regular "Dumore" grinder, but to adapt this machine for the use of a ⅜-inch round carborundum "pencil" and obtain an efficient cutting speed, the machine has been designed for operation at the unusually high speed of 50,000 revolutions per minute.

In order to employ this high speed, it was necessary to make changes in the design of the internal spindle, which is made shorter and more rigid than the spindle of the standard machine; also a specially balanced chuck has been made. In place of the regular driving pulley, a large pulley is cast and this pulley is carefully balanced; power can then be transmitted from the large pulley to a small pulley on the internal spindle to give the required speed. In addition to the usual



"Dumore" Grinder made by Wisconsin Electric Co. for Operation at 50,000 R. P. M.

grinding of button dies, some shops are using the machine to grind a chamfer on the front of the dies in order to break the chips whichever way is most convenient on the class of work that is being handled, *i. e.*, the man who dresses the tools grinds this chamfer to break up the chips or take off a long, continuous shaving as required.

HOSKINS HIGH-RESISTANCE PYROMETER

The utility of any equipment is fixed by the utility of the various units of which it is composed. Thus the worth of a pyrometric equipment depends upon the accuracy and durability of the instrument itself, and upon the desirable properties of the thermo-couples. The one is worth nothing without the other, and the dependency of the instrument is defined exactly by that of the thermo-couple which supplies the operating millivoltage. Inasmuch as it is the thermo-couple, rather than the instrument, that requires renewal, the couples should all have the same properties if they are to be used with a given instrument; that is, they must all generate the same millivoltage under identical conditions, and this millivoltage must not change while the couple is in service. If they do not possess uniform properties, it becomes necessary to calibrate them to fit a given instrument. If the pyrometer itself is of low resistance, it is obvious that the variation of the resistance

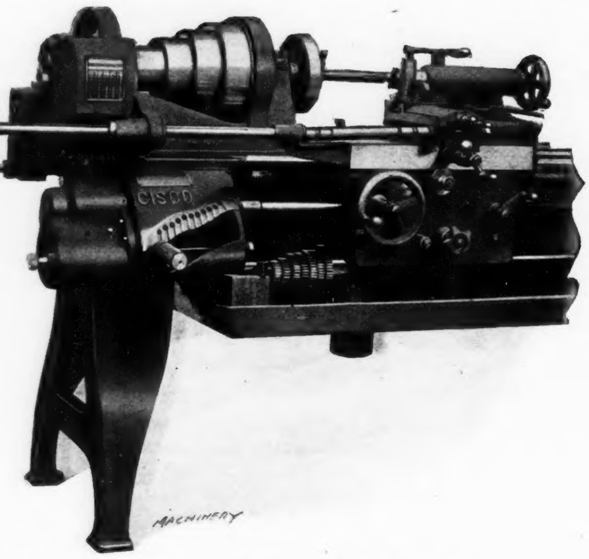
Hoskins High-resistance Pyrometer

of the couple is an important consideration. On the other hand, if the instrument is of high resistance, a variation in the resistance of the couple becomes negligible.

The Hoskins Mfg. Co., 459 Lawton Ave., Detroit, Mich., has developed a new high-resistance pyrometer, together with a special thermo-couple which has one important advantage. The couple requires absolutely no calibration, so that it is possible for the user of this equipment to purchase material for making the elements, in coils, by the pound. When in need of a new thermo-couple, it can be made merely by cutting off suitable lengths of wire and twisting and welding the ends together. No calibration is necessary because of the uniform properties of the wire. The user is thus assured of continuous service from his pyrometric equipment, because of the elimination of delays caused by calibration of new couples. The elements forming this thermo-couple are special chromium and nickel alloys known by the trade name of "194-343." They generate high millivoltage and are said to be long-lived because of their immunity to the action of hot gases.

The illustration shows the instrument to be of the so-called "horizontal edgewise" type; it is said to be more accurate than the vertical type because the balance errors of the needle are practically eliminated. The advantages claimed for high-resistance meters are well known, the principal one being that long couple extension leads may be used, since a change in their resistance caused by outside temperature variations is of no consequence. These meters are made in six ranges, the upper temperatures being 800, 1100, 1400, 1500, 2000 and 2500 degrees F., and it is possible to use thermo-couple "194-343" on all the instruments having any of the three last-named temperature limits.

"CISCO" RELIEVING ATTACHMENT



"Cisco" Lathe equipped with New Relieving Attachment

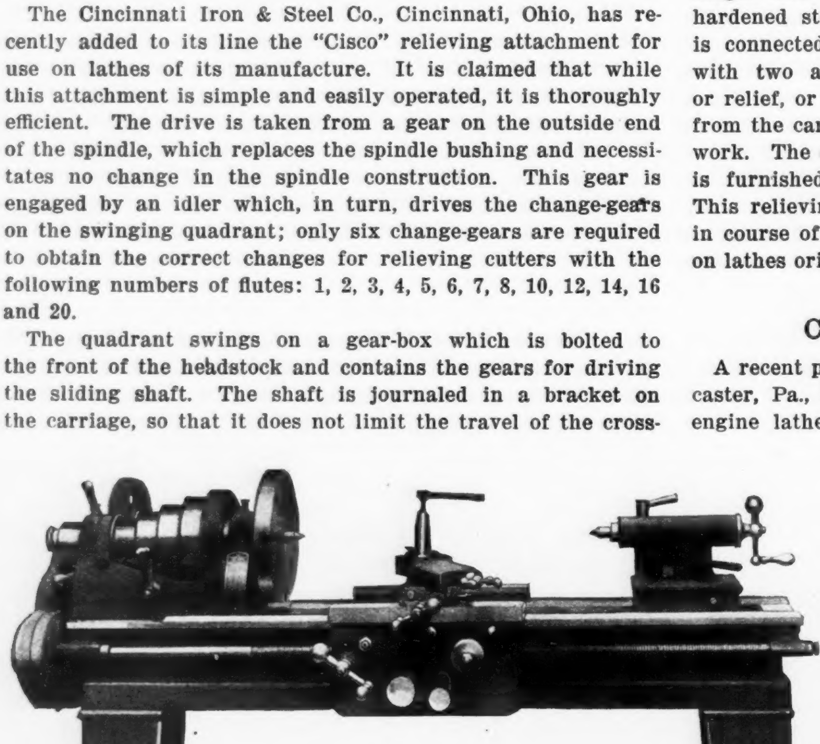
The Cincinnati Iron & Steel Co., Cincinnati, Ohio, has recently added to its line the "Cisco" relieving attachment for use on lathes of its manufacture. It is claimed that while this attachment is simple and easily operated, it is thoroughly efficient. The drive is taken from a gear on the outside end of the spindle, which replaces the spindle bushing and necessitates no change in the spindle construction. This gear is engaged by an idler which, in turn, drives the change-gears on the swinging quadrant; only six change-gears are required to obtain the correct changes for relieving cutters with the following numbers of flutes: 1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 14, 16 and 20.

The quadrant swings on a gear-box which is bolted to the front of the headstock and contains the gears for driving the sliding shaft. The shaft is journaled in a bracket on the carriage, so that it does not limit the travel of the cross-slide when relieving. The drive from this shaft to the cam-shaft is through universal joints and a shaft and sleeve, which compensate for slide and swivel adjustments. The swivel can be turned to an angle of 30 degrees, and all bottom slide and top slide adjustments can be made in connection with the relieving attachment in exactly the same way as in the regular lathe. Relieving can also be done in connection with the taper attachment.

The cam-shaft is readily removed for changing cams, two of which are furnished with each attachment; these are single and double impulse. The cam operates against a hardened steel roller held in a hardened steel slide, which is connected to the top slide screw, and has a spring rod with two adjusting nuts governing the amount of throw or relief, or it can be made to hold the slide and roller away from the cam when the compound rest is required for regular work. The change-gears are well guarded and an index-plate is furnished, which shows the correct gear arrangements. This relieving attachment can either be fitted to new lathes in course of construction or it can be shipped for attachment on lathes originally bought without means of relieving cutters.

CHAMPION ENGINE LATHE

A recent product of the Champion Blower & Forge Co., Lancaster, Pa., is a machine known as the "Lancaster" 13-inch engine lathe, which forms the subject of the following description. It will be seen that this lathe is equipped with a four-step cone pulley, back-gears, positive geared feed, automatic longitudinal feed and power cross-feed, a compound rest, and a screw chasing dial. All parts of the lathe are manufactured with jigs and fixtures so that they are interchangeable. The lead-screw is made of high-carbon steel of special analysis to give the desired durability. All sliding surfaces are carefully scraped, and the spindle and other cylindrical parts are ground to obtain the desired accuracy. Three changes of feed are obtained by simply moving the handle to one of three stations, and the gears are easily changed for cutting threads of different pitch, the range for thread cutting being from 4 to 40 per inch, either right- or left-hand, and including the 11½ per inch pipe thread. By compounding gears, many other threads may be cut.



"Lancaster" 13-inch Engine Lathe built by Champion Blower & Forge Co.

To adapt this lathe for heavy work, the bed is cross-ribbed with box section braces cast at intervals over its entire length. There are three vees and one flat bar for the slot guides of the headstock and tailstock. The rack is made from a solid steel bar. A bearing 15¼

inches in length is provided for the headstock on the bed; and the spindle, which is made of 60-point carbon crucible steel, has a ¾-inch hole for its entire length. The front spindle bearing is 1¾ inch in diameter by 3¼ inches long, and the spindle is bored No. 3 Morse taper. Phosphor-bronze bushings are provided in the spindle bearings, and these are carefully scraped to fit the spindle. The tailstock is offset to allow the compound rest to swing parallel with the bed. A safety device is provided on the apron which prevents throwing in the half-nuts when either feed is connected.

The principal dimensions of this lathe are as follows: swing over shears, 13½ inches; swing over compound rest, 8 inches; swing over carriage, 9 inches; maximum distance between centers for 5-foot bed, 30 inches; size of front spindle bearing, 1¾ inch diameter by 3¼ inches long; size of rear spindle bearing, 1½ inch diameter by 2⅜ inches long; taper of centers, No. 3 Morse; size of cone pulley steps, 7, 5¾, 4½ and 3¼ inches in diameter by 2 inches face width; ratio of back-gears, 8½ to 1; number of spindle speeds, 16; maximum travel of tailstock, 5 inches; maximum travel of compound rest, 4 inches; size of tools used, ½ by 1⅛ inch; and weight of machine with 5-foot bed, 1000 pounds. The regular equipment furnished with this lathe includes a plain or compound rest, follow-rest and steadyrests, change-gears, large and small faceplates, double friction countershaft, and the necessary wrenches for making all adjustments.

GARDNER HEAVY-DUTY DOUBLE GRINDER

The Gardner Machine Co., Beloit, Wis., has recently developed and added to its line of disk and ring wheel grinders, a new double-spindle grinding machine. Prior to the time of bringing out this new No. 15 grinder, the largest of this type on the market had a capacity for 18-inch ring wheels or 20-inch disk wheels. The machine here described carries 20-inch ring wheels or 24-inch disk wheels, both of which types of grinding members are interchangeable. All disk grinding is done dry, but the machine is equipped with a complete water system so that wet grinding may be done when ring wheels are used. A covered opening in the rear of the machine, shown in Fig. 1 directly behind the sliding work-table, is provided for attaching a dust exhaust system. The spindles are 3 inches in diameter by 37¾ inches long. They are accurately ground to size and mounted in removable bronze bushings lined with high quality babbitt, bored, reamed and scraped to a close running fit. Each bearing is 10 inches long. Hardened and ground collars 6 inches in diameter by 1 inch thick are placed on the outer end of the spindles. The fully machined cast-iron spindle pulleys are 12 inches diameter by 8½ inches face width.

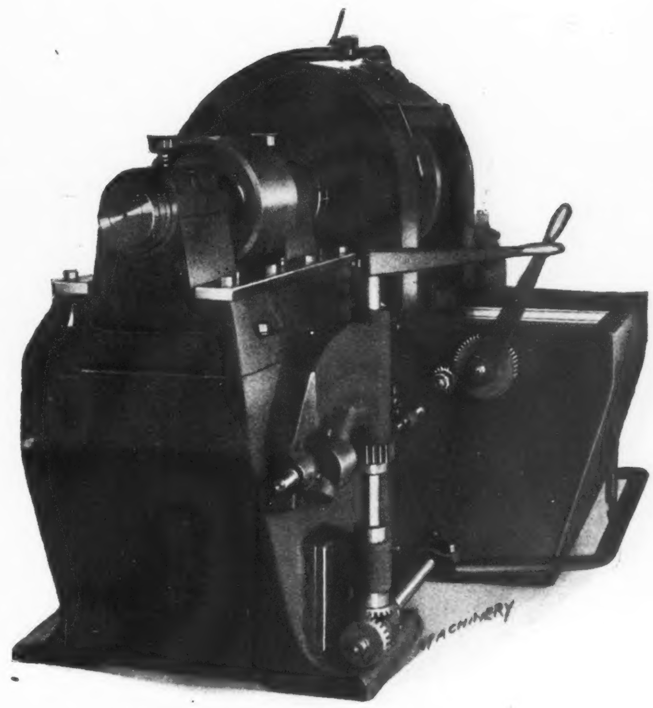


Fig. 2. End View, showing Arrangement of Spindle Head and Sub-base

Fig. 1 shows a front view of the machine. Each spindle is mounted in a sliding head, which, in turn, moves in a sub-base, the latter being firmly bolted in the desired position on the machine base. This construction is shown quite plainly in Fig. 2. The cast-iron hood ends are fastened to the sub-base and move only when the latter are adjusted for position. The sliding heads work through a felt-lined hole in the hoods and have a combined lateral travel in the sub-base of 3½ inches, which is more than would be required in actual practice. As shown in Fig. 1, the sub-bases are set for grinding opposite sides of very wide pieces; but, if it were desired to grind parallel sides, the sub-bases would be moved toward the center and bolted down. A wrench placed on the two pinions appearing beneath each pulley makes this adjustment an easy matter. It will be seen that with this hood construction the ways for the sliding heads are always protected against grit and dirt.

The sliding work-table in the center of the machine is shown in Fig. 1. The fixture holding the piece of work to be finished is mounted on this table, and the whole is moved in and out between the grinding wheels by means of a hand-lever, pinions and rack attached to the under side of the table. The lever and gears are shown more distinctly in Fig. 2. As shown here, the large gear is the driver, but these two gears can be reversed when a slower and more powerful stroke is required. The shafts carrying the gears are extended across and underneath the sliding table through the other side, so that if desired the same gears and lever can be mounted on the right-hand side of the water basin. The entire base of the machine is cored out with solid bottom and connected to the water basin in front, giving a capacity of approximately seventy gallons of water or grinding compound.

Fig. 3 is a close view of the left-hand end of the machine, showing the feed mechanism, micrometer stop-screw and adjustable back-stop. A 3-inch square steel bar, carrying a rack on the top, is supported in ways at each end and extends practically across the entire front of the machine. At the left-hand end of this bar is attached in front a short rack which engages with a pinion on the hand-lever shaft. By pulling the

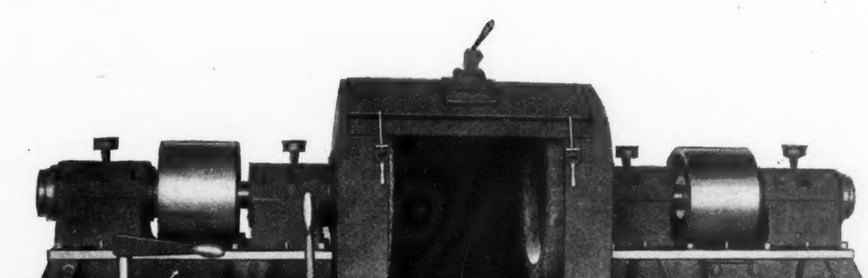


Fig. 1. Front View of Gardner No. 15 Disk and Ring Wheel Grinder

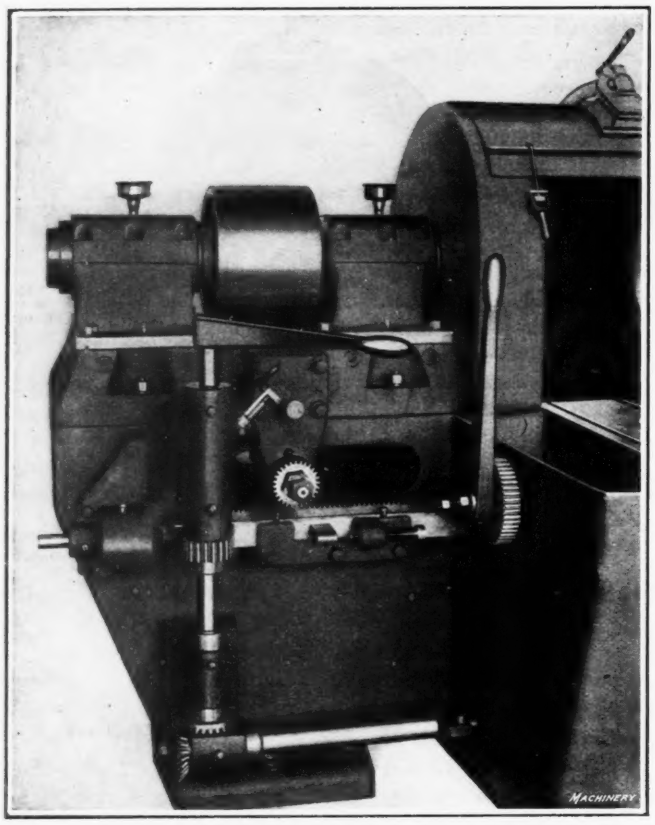


Fig. 3. Close View of Feed Mechanism, Micrometer Stop-screw and Adjustable Back-stop

horizontal hand-lever to the right the long feed-bar moves to the left, which action causes the two feed-gears to turn in the opposite direction. These gear shafts carry bevel pinions which engage with a gear on the bottom of the vertical shafts mounted in the sub-bases. At the top of these vertical shafts, pinions are attached which mesh with racks fastened to the under side of the sliding heads. The rack on the left-hand head is fastened on the front side of the head center line, and on the right head the rack is attached back of the center. This relation causes the heads to move in opposite directions, or toward and away from each other. By means of bevel gears the hand-lever is connected to the foot-treadle. A coil spring attached to the foot-treadle forces the heads back when the pressure is removed.

A micrometer stop-screw is located at the extreme left in line with the feed-bar. As previously explained, the sliding heads move toward the center of the machine, the feed-bar moves to the left and butts against the micrometer screw. A worm nut adjusts this hardened screw and is acted upon by a worm on the inclined shaft which terminates directly behind the hand-lever with a small graduated handwheel. The back-stop screw is located a little farther to the right and forms a part of the feed-bar gib. A hardened block is attached to the feed-bar and comes in contact with the hardened back-stop screw, thereby limiting the backward travel of the sliding heads. It should be mentioned that suitable covers are regularly provided for all gears and racks, but are removed in the illustrations in order that the construction may be more plainly seen.

It will be seen from the preceding description that both heads move simultaneously toward the center, but if desired either may be locked in position and only one moved. The greatest opening between the disk wheels is 24 inches, and between the ring wheels, 20 inches. The over-all dimensions of this machine are 95 inches long by 51 inches wide. Its weight, exclusive of any grinding wheels, wheel press or countershaft, is 5000 pounds.

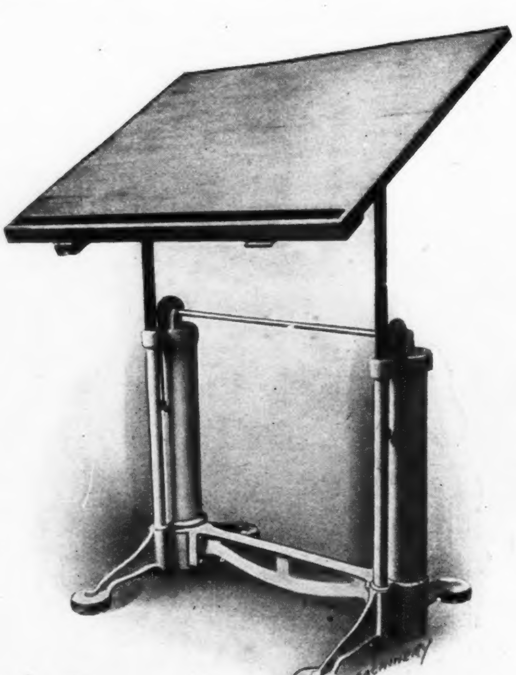
IMPROVED DRAFTING-BOARD

It is generally known that the draftsman's work subjects him to considerable physical strain, and this is particularly true when he is working on large drawings. Men of different stature naturally need drafting-boards set in different positions if they are to work in the most comfortable posture. With the view of enabling advantage to be taken of this condition, the Improved Drafting Board Co., Nashua, N. H., has recently developed what is known as the "Universal" drafting-board, which is designed to suit the tastes and requirements of all draftsmen, whether users of the horizontal or upright boards. This new drafting-board may be used in either a horizontal or upright position with equal effectiveness, and it may be set at intermediate angles between these positions.

Three advantages are claimed for the "Universal" drafting-board when used in a horizontal position: First, the board is generally inclined a few degrees from the true horizontal, but the angle of inclination may be quickly increased or diminished to meet requirements. This enables the draftsman to bring the upper edge of the board nearer his eyes when necessary, instead of forcing him to stretch over the board and strain both his body and eyes. Second, the same board can be used by both short and tall men, either sitting or standing, since the height can be easily adjusted to suit men of different stature and draftsmen who work in various postures. Third, when set to the required angle and height, the drafting-board is held absolutely stationary.

Used in a vertical position, this drafting-board will be found useful by those who are finding in this position a way to more efficient and hygienic work. When used upright, the board is generally inclined a few degrees from the vertical, but this inclination can be adjusted according to the requirements of different users. Attention is called to the fact that the convenience of the "Universal" drafting-board in this position lies in the fact that the draftsman can raise or lower the board by applying a slight pressure of the hand, and the value of this feature is not likely to be overestimated. Draftsmen using an upright board are frequently required to bring different sections of the board opposite the eye, and if the making of such changes requires considerable physical effort, this not only leads to unnecessary fatigue, but interruptions are likely to cause important details to be overlooked in working out designs. Using the board in a vertical position, draftsmen may either sit or stand, and the board may be instantly set so that it is stationary in any required position.

Both the horizontal and vertical positions are frequently used, but, as its name implies, the "Universal" drafting-board can also be set to any other position between the horizontal and vertical. The board is provided with an automatic parallel rule which is capable of being set to any angle with the horizontal, and so attached to the board that there is no inter-



"Universal" Drawing-board made by Improved Drafting Board Co.

ference with the length of drawings. The lower part of the frame is designed to form a foot-rest, and wooden blocks covered with felt prevent scratching the floor. Directly beneath the board there is a cabinet fitted with compartments for storing instruments and other drawing equipment. The board may be furnished with or without the cabinet, and with or without the Improved Drafting Board Co.'s standard reference table. The metal frame is enameled white and finished with nickel-plated fixtures, while the board is made of narrow strips of kiln-dried pine. The standard board takes drawings up to 28 by 40 inches in size, while larger drawings may be attached to the back of the board and rolled over the edge.

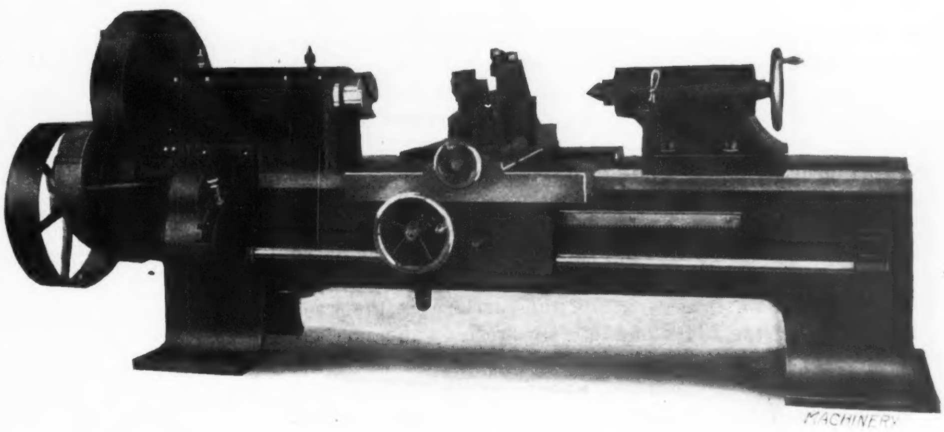


Fig. 3. Pottstown 24-inch Lathe for machining Shells from 9 to 12 Inches

POTTSTOWN LATHES

The machine illustrated in Fig. 1 is fundamentally a single-purpose lathe, being designed for the rapid machining of 3-inch shells. It is constructed along simple lines, with the primary idea of removing metal at the maximum rate. As there is no necessity for a cross-feed, the carriage only has longitudinal power feed. There is a choice of three feeds, *i. e.*, 1/64, 1/32 and 1/16 inch per revolution. The feed is changed by a handle on the simply constructed gear-box, which is placed conveniently in front of the lathe to the left of the operator.

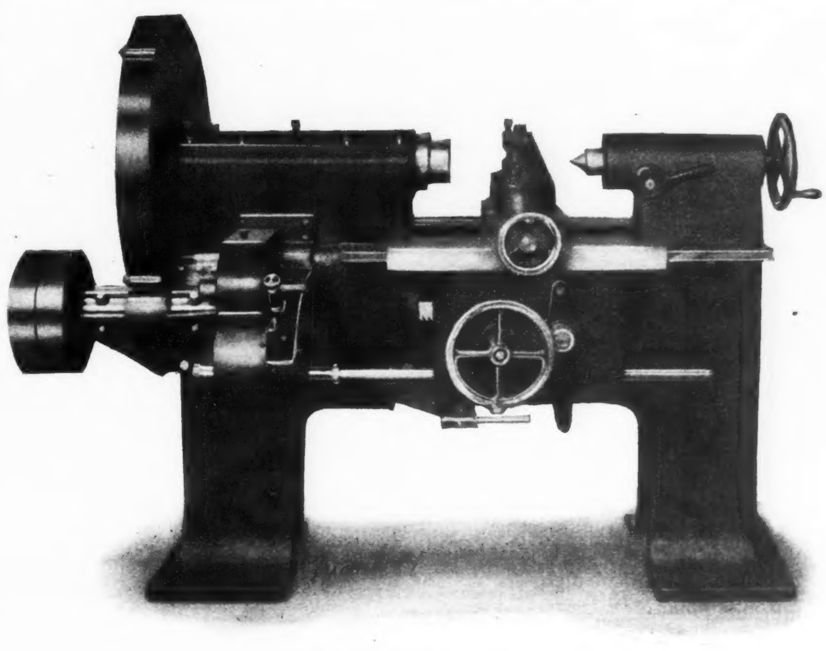


Fig. 1. Lathe for machining 3-inch Shells, built by Pottstown Machine Co.

Power is transmitted from a motor to a single pulley, attached to the end of the shaft shown on the front of the lathe; this is a high-speed shaft, which runs in bronze bearings and is supported by the bracket attached to the front of the frame. This driving shaft carries a 4-inch pinion which engages with the 28-inch master gear on the main spindle, affording a positive drive. The driving pulley is 12 inches in diameter by 5 inches wide. The diameter of the main spindle is 3 15/16 inches, and it runs in scraped babbitt bearings of liberal proportions. The headstock as well as the tailstock are cast integral with the lathe bed, thereby affording the greatest possible rigidity.

The diameter of the tail-spindle is 2 15/16 inches, and it is provided with a No. 4 Morse taper. The distance between centers is 14 inches maximum, this being sufficient provision for 3-inch shells. The carriage is provided with two toolposts and an automatic trip for the feed. The lever which throws the feed into engagement has an extension that contacts with an adjustable rod held by a bracket fast to the bed of the lathe. By setting this rod at the correct position, the carriage may be stopped automatically wherever desired.

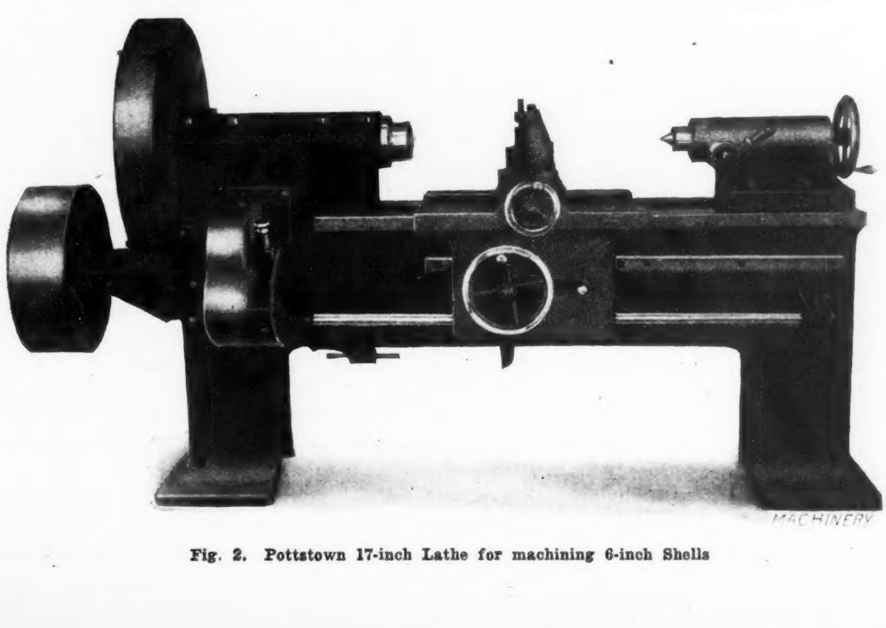


Fig. 2. Pottstown 17-inch Lathe for machining 6-inch Shells

The general lines of the 17-inch lathe, illustrated in Fig. 2, are similar to the one just described, and it was designed primarily for the making of 6-inch shells. Unlike the 3-inch lathe, this machine has a separately attached tailstock that may be adjusted in the ordinary way. The general dimensions are as follows: diameter of spindle, 4 7/16 inches; distance between spindle head and tailstock, 30 inches, maximum; diameter of tail-spindle, 2 15/16 inches; size of driving pulley, 20 inches diameter and 6 inches face width; ratio of pulley speed to spindle speed, 7 to 1; diameter of spindle gear, 28 inches; and swing over bed, 17 inches. The carriage is provided with two toolposts, and there are three variations of feed, namely, 1/64, 1/32 and 1/16 inch per revolution.

The 24-inch lathe, shown in Fig. 3, was designed primarily for machining

shells from 9 to 12 inches, and it is not only adaptable for large shell work, but is also well suited for turning rough forgings. This lathe is ordinarily 10 feet long over-all, but it may be had in any length up to 20 feet. The general dimensions are as follows: diameter of spindle, 6 inches; distance between spindle head and tailstock, 4 feet, 9 inches, maximum; size of driving pulley 28 inches diameter and 6 inches face width; pulley ratio to spindle, 16.6 to 1; diameter of spindle gear, 28 inches; swing over bed, 24 inches; and diameter of tail-spindle, 3 15/16 inches. The carriage is equipped with two toolposts, and the lathe is provided with a range of three feeds, *viz.*, 1/32, 1/16 and 1/8 inch per revolution. The length of the carriage on the ways is 36 inches and the width of the cross brace on the carriage is 12 inches. All of these lathes, which are built by the Pottstown Machine Co., Pottstown, Pa., have no provision for change of spindle speed within themselves, although various speeds are obtainable from a variable-speed motor with which they are equipped.

M. E. C. THREE-JAW AIR CHUCK

The Manufacturers Equipment Co., 175-179 N. Jefferson St., Chicago, Ill., has recently added to its line a three-jaw air-operated chuck intended for handling light, medium and heavy work. With the view of furnishing ample strength, all parts of the chuck are made of steel, and reference to Fig. 3 will show that the mechanism consists of a combination of gears, racks and levers, the design being worked out in such a way that large contact surfaces and high leverage ratios are provided for handling heavy work. Provision of high leverage ratios also permits using a smaller air cylinder than would otherwise be possible, and for exceptionally heavy work a larger cylinder can be provided to afford the necessary grip.

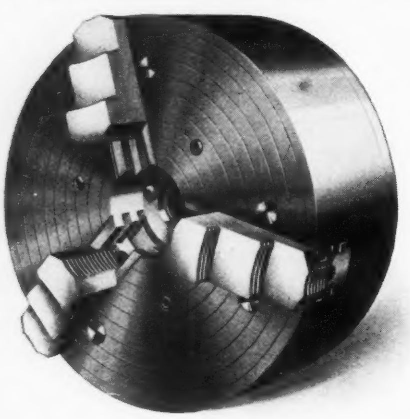


Fig. 1. M. E. C. Three-jaw Air-operated Chuck

This three-jaw air-operated chuck may be used in place of manually operated chucks for work handled in small quantities, and where manufacturing operations are being performed on large quantities of work of the same kind, the rapidity of operation is the means of making a material saving in the cost of production. These chucks are furnished with regular step jaws or with jaws for use in connection with "false" jaws for chucking pieces of irregular shape. The claim is made that these air-operated chucks are the means of increasing production from 25 to 75 per cent. The way in which this saving is effected will be readily understood when it is realized that a large proportion of medium-sized work can be chucked and released without stopping the machine spindle; this fact, together with the ease of operation, which merely requires the moving of a valve handle, enables the operator to pay more attention to the maintenance of a high rate of production than would otherwise be the case. M. E. C. three-jaw air-operated chucks are regularly made in 8-, 10-, 12-, 15- and 18-inch sizes, while larger chucks will be made to special order.

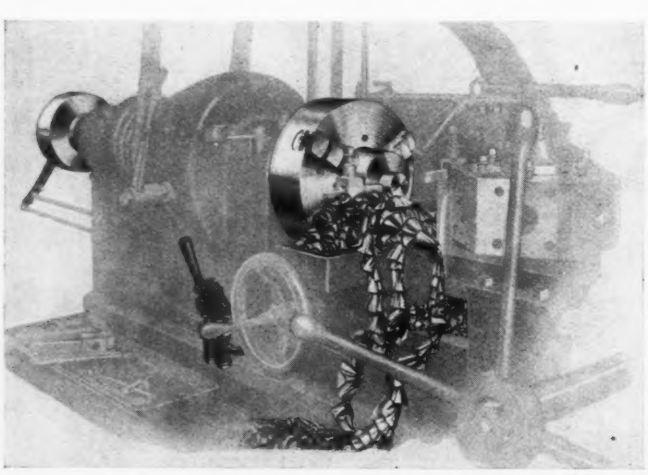


Fig. 2. M. E. C. Three-jaw Air-operated Chuck in Use on Lathe

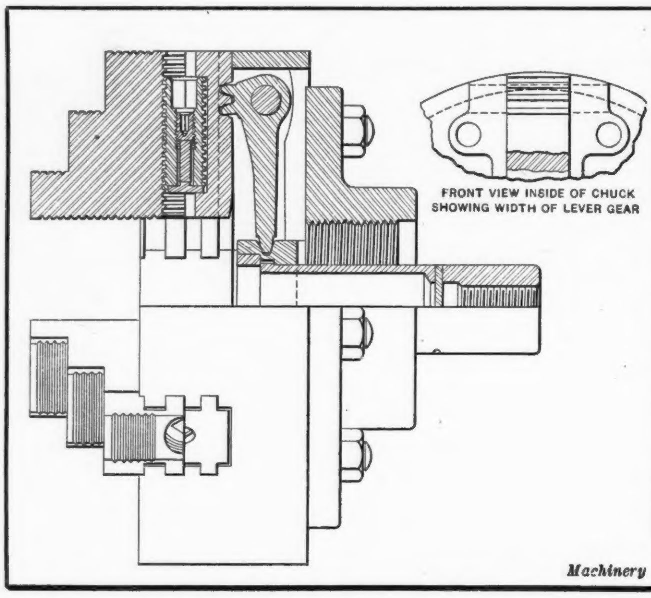
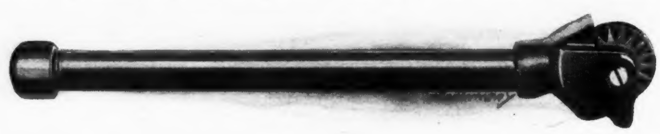


Fig. 3. Mechanism of M. E. C. Air-operated Three-jaw Chuck

HETHERINGTON-McCABE GRINDING WHEEL DRESSER

A tool known as the "Brandenburg" self-lubricating grinding wheel dresser is now being manufactured by the Hetherington-McCabe Co., Piqua, Ohio. In working out the design, particular care has been paid to developing a construction that makes it practically impossible to wear out the bearings. This result is obtained by the combination of a hardened steel spindle and a cast-iron bearing lubricated with flake graphite. The particular claim made for the graphite is that it does not tend to catch emery dust and hold it in the bearings. Not only does the graphite prevent trouble from holding abrasive which would rapidly destroy the bearing, but it also fills the pores of the cast iron and provides a bearing surface that is not affected by heat and that is practically frictionless. The cutters start to spin almost immediately when placed in contact with the wheel, so that they perform their function of dressing and truing the wheel instantly without grinding off the points of the cutter. It is claimed that this dresser will never become hot and will never draw the temper of the cutters. A safety hood provided over the cutters prevents sparks or abrasive from flying into the workman's eyes, and the chamber or hollow handle is filled with flake graphite, a sufficient supply being carried to last for several months.



"Brandenburg" Grinding Wheel Dresser made by Hetherington-McCabe Co.

This tool is always ready for use without requiring attention, and a feature of the graphite lubrication, in addition to eliminating the tendency that oil has to hold abrasive in the bearings, is that no oil can be thrown on the grinding wheel and cause it to glaze. Graphite is fed to the bearings by gravity and vibration. This dresser uses standard cutters, 1⅛ inch in diameter, as well as a larger cutter 1⅝ inch in diameter with a ⅜-inch hole, which are said to give increased service on wheels down to 6 inches in diameter by ½ inch face width, although, possibly, greater accuracy can be secured

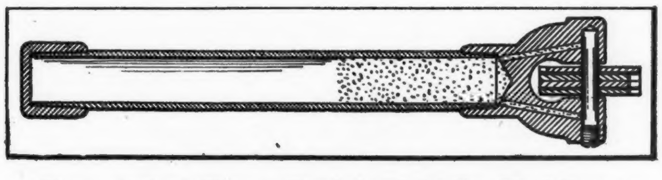


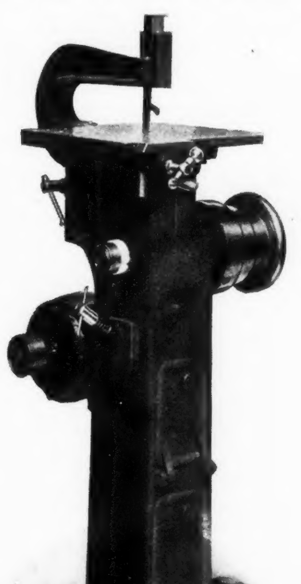
Fig. 2. Sectional View of "Brandenburg" Grinding Wheel Dresser, showing Provision for Lubrication

with the standard cutters of 1⅛-inch diameter. From the preceding statement it will be apparent that the two sizes of cutters are interchangeable in the "Brandenburg" holder.

OLIVER SAWING, FILING AND LAPPING MACHINE

In the December, 1915, number of MACHINERY a description was published of a bench type of combination sawing, filing and lapping machine which had just been placed on the market at that time by the Oliver Instrument Co., 1168 Cass Ave., Detroit, Mich. Recently this firm has brought out a floor type of machine, the upper part of which is of similar design to the bench type formerly manufactured. This machine is intended for the heaviest classes of work in making dies, gages, templets, and similar parts, in addition to which it may be employed in certain classes of manufacturing.

All moving parts are enclosed and run in a bath of oil, and all bearings are carefully protected from dirt and dust; the reciprocating parts are balanced so that the action of the machine is quite smooth. The table is 12 inches square and tilts to any angle up to 10 degrees either way from the center. This table is fitted with a slide which has a travel of 5 inches and is operated by a screw; the slide is 4 inches wide and has three rows of tapped holes, by means of which the piece being operated upon can be solidly clamped and fed to the saw or file. Various fixtures are provided for holding the work.



Oliver Sawing, Filing and Lapping Machine with Pedestal Base

An over-arm is used for sawing, and the depth of throat is sufficient to provide for working to the center of a 19-inch circle. Saws of various widths can be used, and the irregular outline of a die may be followed closely, leaving a minimum amount of metal to be removed by the filing operation. As illustrated, the machine is equipped with motor drive, and it will be seen that the motor is attached to the pedestal and belted to a jack-shaft at the base, a three-step cone pulley allowing various speeds to be obtained for working different materials. Tight and loose pulleys can also be provided for belt drives, and the shifter extended through the pedestal and actuated by a treadle at the base of the machine. Doors in the pedestal open out against stops and have pockets on the back to hold fixtures and tools.

G. E. LIGHTING FIXTURE

In one of the suburbs of Buffalo, there has recently been installed a new type of ornamental street lighting unit, which is both efficient and economical. This type is equally suitable for lighting large open spaces, such as docks, lumber and railroad yards, platforms at railroad and interurban street railway stations, and streets and open places in industrial plants. In the old type of lighting unit, a large proportion of the rays are thrown upward and lost, while those of the new unit are all directed at a downward angle to the surfaces where illumination is needed.

An artistic fixture contains a prismatic refractor used to collect the upward rays of the 100 candlepower Mazda C lamp used in this case, and directs the light outward at a slight downward angle. This saves and applies to a useful purpose the light which is thrown upward and wasted with the average installation. The candlepower of the light with this unit may vary, but the Mazda C lamp should be used without exception. This unit is the latest addition to the line of out-of-door lighting fixtures made by General Electric Co., Schenectady, N. Y.

G. E. Ornamental "Refractor" Lighting Fixture

AMERICAN AMMUNITION CO.'S THREAD MILLER

For performing internal and external thread milling operations in munition factories, the American Ammunition Co., Inc., Bordentown, N. J., has recently developed a semi-automatic machine that is used in connection with either hand- or power-feed milling machines. While especially developed for the class of work referred to, this thread miller is also adapted for cutting threads in many other classes of work.

The spindle is fitted with a collet that has a capacity of 1¾ inch on pieces not more than 4 inches long, and 1 inch clear through the spindle. It is adapted for either inside or outside milling, and by changing the lead-nut and screw provision can be made to cut any pitch up to ½ inch, either right or left hand. It is used with a multiple-tooth straight, relieved cutter, and finishes the work at one revolution. Where a final finishing cut is required, by changing one screw the machine will automatically make two revolutions, one for roughing and the other for finishing. The spindle, gears and lead-screws are casehardened, and the nut is made of bronze, with provision for taking up wear. It will fit any hand- or power-feed milling machine, and where a greater angle is being

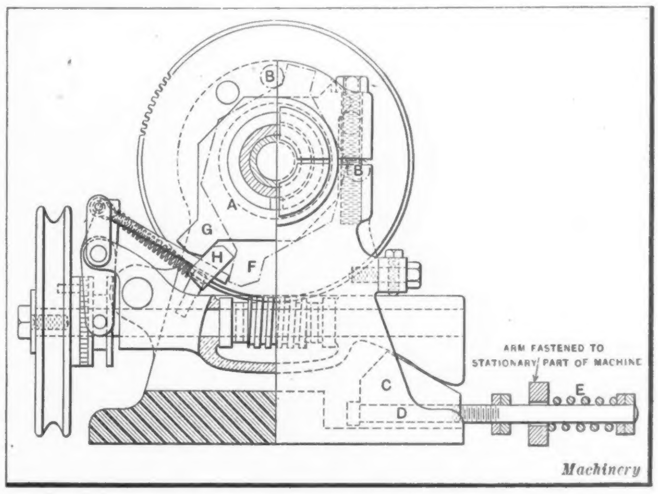


Fig. 1. Mechanism of American Ammunition Co.'s Thread Miller, showing Principle of Semi-automatic Operation

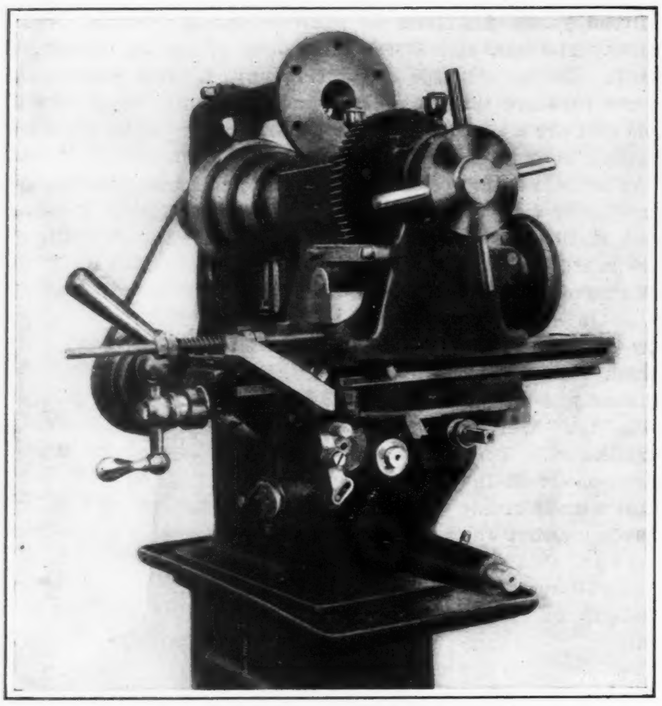


Fig. 2. American Ammunition Co.'s Thread Miller for Internal and External Threads

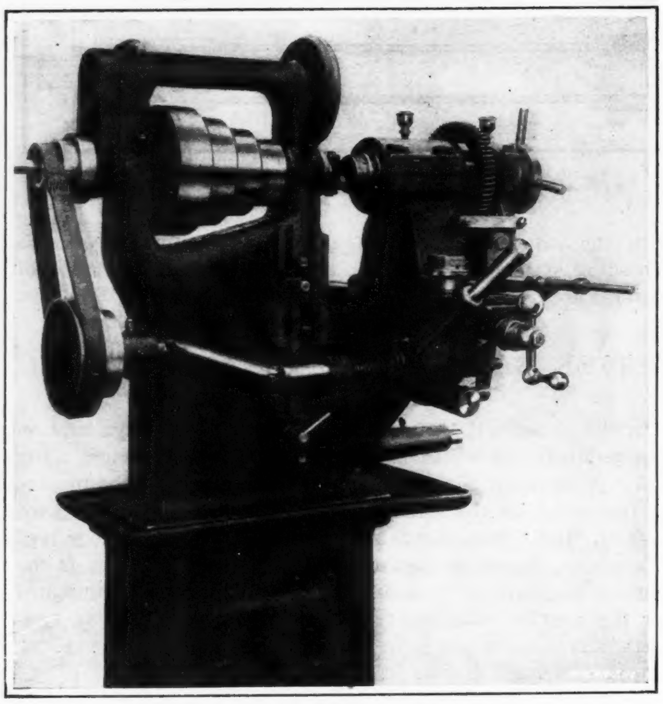


Fig. 3. Side View of American Ammunition Co.'s Thread Miller set up on Hand Milling Machine

cut than can be taken care of with the clearance of the cutter, this milling attachment can be raised or lowered so that the cutter will be directly underneath or on top of the work, when the attachment can be set at the proper angle to clear the threads.

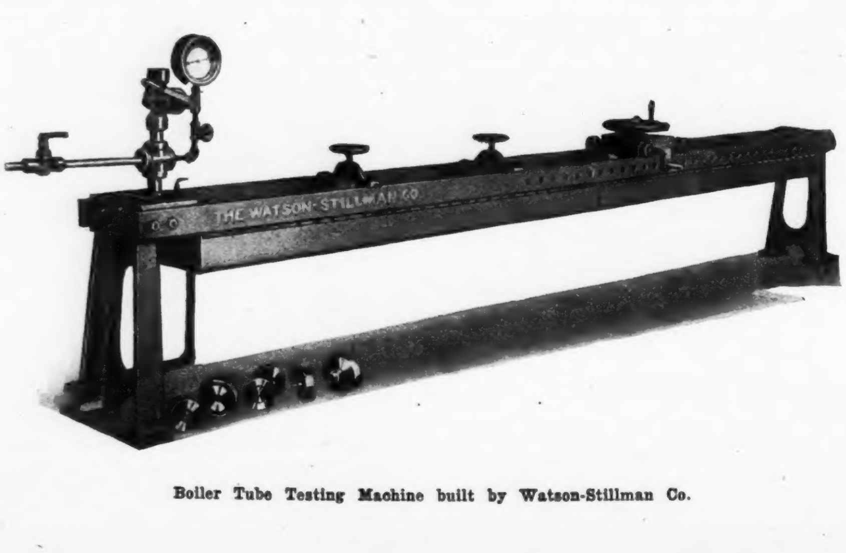
A stop-plate *A*, Fig. 1, revolves loosely on the gear hub and is stopped by the two pins *B* giving a total of about 1 1/10 revolution to the spindle. The worm is brought into contact with the worm-wheel by wedge *C*, which is attached to a stationary part of the frame or knee of the milling machine, so that a forward motion of the table with the milling attachment automatically raises the worm into contact with the gear and starts the machine, while a withdrawal of the work reverses this motion and releases the worm. Rod *D* passes through a hole in the arm, being regulated in its motion by two pairs of lock-nuts. Behind the lock-nuts for raising the arm is a spiral spring to bring the arm into full contact and start the work revolving before the cutter is in contact, additional forward motion of the table to the full depth being possible by the compression of spring *E*. The feed pulley is driven by a round belt from the countershaft and operates continuously.

With the table run back, the piece to be threaded is placed in the collet, and the collet is closed by a pilot wheel; this motion revolves the spindle until the loose stop-plate *A* comes against the stop *H*. The table is then run forward by a lever or screw, which automatically brings the worm into mesh and starts the work revolving, the motion beginning just before the cutter comes into contact with the work. It begins revolving and runs continuously until the loose stop-piece comes into position *F*, which throws out the clutch and leaves the machine standing. On bringing the table back, the worm drops and releases the wheel, when the collet may be opened by means of the handwheel, allowing the threaded work to be taken out and another piece substituted in the collet; the screwing up of the collet again brings the wheel to the starting point *G*. The machine is automatic in its operation, the only hand operations being the backward and forward movement of the table, and the opening and closing of the collet. For internal work it is also necessary to move the cross-slide of the machine.

WATSON-STILLMAN BOILER TUBE TESTING MACHINE

The Watson-Stillman Co., 192 Fulton St., New York City, has added to its line of hydraulic machinery a new testing machine for subjecting boiler and other tubing to internal hydrostatic pressure. This machine is designed to be used either with a hand- or power-driven pump, so that it is adaptable either for use in shops doing only occasional testing or for large capacity. The machine consists of a frame with two rectangular tie-bars, at one end of which is a stationary abutment; and at the other end there is a moving abutment in the form of a carriage mounted on rollers, which can be adjusted to the length of the tubes to be tested and secured to the side frames by pins; and a high-pressure hydraulic pump to subject the tubes to a predetermined internal hydraulic pressure.

The tube to be tested is placed in the machine with one end against the fixed abutment; the moving abutment is then brought to bear against the other end of the tube pinned to the frame, and the tube is made pressure-tight by turning the handwheel. Two intermediate clamps operated by small handwheels prevent the tube from buckling while under pressure. The tube is then filled from a water main, overhead tank or by the low-pressure pump. After the tube is filled, a high-pressure hand or power pump is used to raise the pressure to the desired test, as shown on the gage.



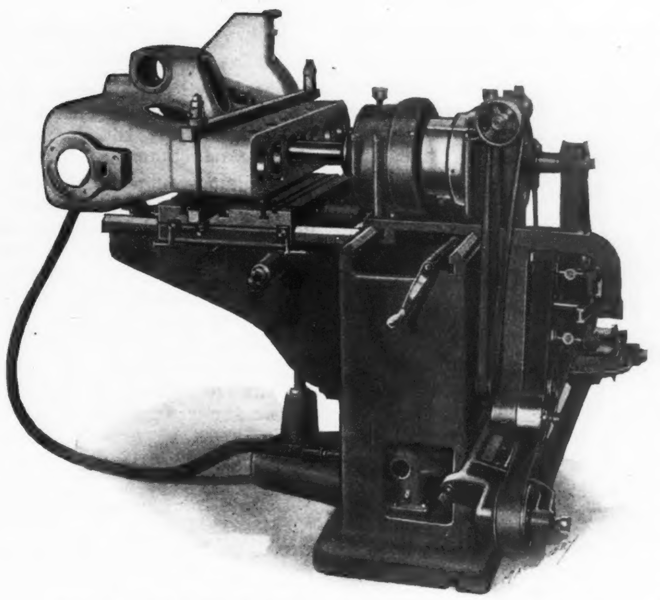
Boiler Tube Testing Machine built by Watson-Stillman Co.

There is a pan under the bed of the machine to catch the waste water, which

serves also as a reservoir if a pump is used for the initial filling. The machine illustrated is designed to test boiler tubes up to 4½ inches outside diameter to a pressure of 1200 pounds per square inch. The minimum opening is 5 feet and the maximum opening 15 feet, and the weight of the machine is 2000 pounds. Other sizes of the same general design can be built to meet special requirements.

OLSON CYLINDER GRINDING MACHINE

The Olson cylinder grinding machine which forms the subject of the following description is manufactured by the T. C. Olson Machine Co., Madison, Wis., and the E. A. Fuller Sales Co. of the same city is the sales agent. This machine was first developed by T. C. Olson, who operated a machine shop doing repair work for several garages, in the handling of which there was need for a cylinder grinder. Machines available at that time for handling work of this kind were so expensive that Mr. Olson did not feel justified in investing in a cylinder grinding machine. Eventually he reached the conclusion that a satisfactory grinder for his work could be made at moderate cost, and this led to the design and construction of the original machine of this type. It proved very satisfactory in operation, and several machine tool salesmen and garage owners were so favorably impressed with the results obtained that Mr. Olson finally decided to put the machine on the market. With this object in view, the T. C. Olson Machine Co. was formed.



Olson Cylinder Grinding Machine with Work set up for grinding

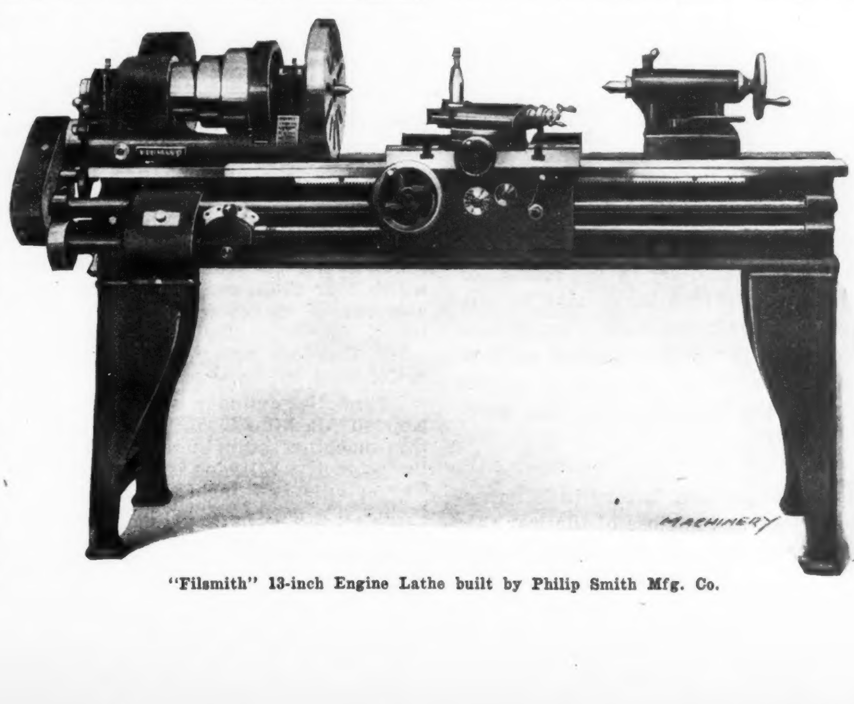
Among the features of design of this machine the following may be mentioned: An automatic belt-tightening device maintains a uniform tension on the belt regardless of the position of the head on the body of the machine. After the cylinder has been set, it is only necessary to shift the grinding head in order to bring successive holes into position for grinding. The table has only a forward and backward motion, which takes care of the feed and gives a particularly rigid construction for the table. An adjustable automatic feed tripping device is provided, and after this has once been set, the feed is automatically tripped at each end of the travel. The head which carries the grinding spindle is adjustable by means of a double eccentric motion, which enables the grinding wheel to move from the center to the position of maximum capacity. This grinding head is furnished with a fine micrometer adjustment to facilitate grinding work to exactly the required size. The machine will handle any cylinder from that of the smallest motorcycle engine up to cylinders 8 inches in diameter, and work ranging from single-cylinder blocks up to blocks with six holes may be handled with equal facility. The drive may be by either individual motor or belt; and the regular equipment includes a pair of angle-irons for truing up the castings on the table.

The principal dimensions of the machine are as follows: minimum size cylinder that can be ground, 2⅜ inches in diameter; maximum size cylinder that can be ground with 5-inch wheel, 8 inches in diameter; maximum capacity of head and spindle in cross adjustment, 27 inches; maximum travel of table or length of hole that can be ground, 15 inches; maximum vertical distance from top of table to spindle center, 9 inches; minimum vertical distance from top of table to spindle center, 3 inches; speed of wheel-spindle, 5000 R. P. M.; rate of feed, 1/8 and 3/16 inch; diameter of revolving head boxes, 7¾ inches; length of revolving head boxes, 4 inches; length of bronze wheel spindle bearings, 6 inches; power required for driving, 3 horsepower; maximum height of machine, 44 inches; floor space occupied, 64 by 56 inches; and net weight, 1600 pounds.

"FILSMITH" ENGINE LATHE

The Philip Smith Mfg. Co., Sidney, Ohio, is now manufacturing the "Filsmith" 13-inch engine lathe equipped with a three-step cone pulley and double back-gears. The headstock is braced with heavy webs to insure rigidity under the heaviest cuts. Fifty-point carbon crucible steel is used for making the spindle, which is finished by grinding; and the spindle bearings are lined with phosphor-bronze. Rigidity is further provided for by making the bed with heavy walls and box girders cast at frequent intervals. The tailstock is so shaped that the compound rest can be set at right angles when turning work of small diameter.

A bearing 18 inches in length is provided for the carriage on the vees, and the bridge is 7¼ inches wide and furnished with T-slots for clamping special work. The compound rest is provided with taper gibs and graduated in the usual way for handling angular work. The apron and its bearings are cast in one piece, making a stiff, rigid construction; and all holes in the apron are drilled, tapped and reamed in a jig. All small gears are made of steel, and the studs are of steel, hardened and ground. A safety device prevents throwing in half-nuts when either feed is connected, thus preventing breakage. Screws for actuating the power cross-feed and compound rest are provided with the usual graduated dials; and the lead-screw is cut from a master screw which is frequently tested for accuracy. The spindle bearings in the headstock are of the self-oiling type. It will be seen that a quick-change mechanism is provided by means of which four changes of feed are instantly obtainable. All gears are thoroughly guarded to meet the safety requirements of the different states. Steel is used for making the feed-rack, and all sliding surfaces are carefully scraped to a bearing, while all cylindrical parts are ground to size.



"Filsmith" 13-inch Engine Lathe built by Philip Smith Mfg. Co.

The standard equipment furnished with the machine includes a compound rest, follow-rest, steadyrest, double friction countershaft, and the necessary wrenches for making all adjustments. Special equipment obtainable for use in connection with this machine includes the following: No. 3 draw-in chuck, with capacity up to 7/8 inch; No. 2 draw-in chuck, with capacity up to 5/8 inch; chuck plates; taper attachment; automatic stop; and chasing dial. This lathe is built with beds 6, 8 and 10 feet in length.

The principal dimensions of the machine are as follows: swing over bed, 13 1/4 inches; swing over carriage, 8 1/4 inches; distance between centers for 6-foot bed, 35 inches; maximum tailstock travel, 5 1/4 inches; diameter of tailstock spindle, 1 3/4 inch; size of front spindle bearing, 2 3/4 by 4 inches; size of rear spindle bearing, 1 13/16 inch by 3 inches; diameter of hole through spindle, 1 5/16 inch; diameter of spindle nose, 2 1/16 inches; capacity for thread cutting, 4 to 20 threads per inch; size of cone pulley steps, 5 1/2, 6 3/4 and 8 inches in diameter by 2 1/2 inches face width; ratio of back-gears, 3 to 1 and 8 to 1; number of spindle speeds, 18; countershaft speeds, 300 and 400 revolutions per minute; range of spindle speeds, 27 to 600 revolutions per minute; toolpost capacity, 1 1/4 by 5/8 inch; and net weight of machine with 6-foot bed, 1250 pounds.

SILBERBERG MOTION STUDY WATCH

The instrument illustrated has recently been brought out by Mortimer J. Silberberg, 122 S. Michigan Ave., Chicago, Ill., and its design comprises an improvement on previous time study watches and stop watches, inasmuch as a decimal computed dial has been combined with a high-grade split hand watch. The split hand watch with a decimal computed dial has become a necessity, as time and motion study has been steadily advancing and our industries have been demanding a greater refinement of the original single hand instruments, in order to keep pace with the more complicated motion problems which are constantly arising.

Motion Study Watch developed by Mortimer J. Silberberg

This watch has a decimal dial, divided in tenths and hundredths of a minute, and contains figures spaced two hundredths of a minute apart, indicating at any point of elapsed time exactly what the corresponding hourly production would be. This feature is identical with the time study watch which was the original instrument placed on the market. The combination of this dial, however, with a split hand watch constitutes an improvement which will greatly facilitate time and motion study in that at one observation both the productive and non-productive time of an operation can be obtained, whereas, heretofore, on the single hand instruments two readings were necessary to obtain this result.

The computations on the dial have been described in the past, but it may be mentioned that they denote pieces or operations per hour. The watch embodies two hands, one of which is controlled by the side plug, and the other by the crown; or if it is desired to use both as a unit, both hands may be controlled by the crown. The crown-controlled hand may be used to determine the gross time, and the plug-controlled hand to take out the non-productive time, or delays, thereby at one reading giving an observer both the gross and net of an operation.

* * *

Belgian diamond cutters have opened a factory in Birmingham, England. It is possible that at the close of the war this city will become a rival of Amsterdam and Antwerp in this industry.

NEW MACHINERY AND TOOLS NOTES

Lathe with Relieving Attachment: Springfield Machine Tool Co., 631 Southern Ave., Springfield, Ohio. This lathe is made especially to cut metric threads and has a cutter relieving attachment.

Precision Gages: Superior Machine & Engineering Co., Detroit, Mich. This company is now making precision gages of all kinds and is paying especial attention to thread gages of both the plug and ring type.

Solidified Oil: Sun Co., Toledo, Ohio. "Nusco" is an oil solidified with tallow to a jellylike consistency, which is intended for use in grease cups; it is claimed that the mixture can be used satisfactorily at temperatures much below 0 degrees F.

Universal Square: D. J. Kelsey, New Haven, Conn. This instrument, which is made of celluloid, consists of a square, to the inner angle of which a movable arm is attached. The piece above this arm is graduated and the arm may be quickly set to the more common angles and held firmly by a thumb-screw.

Double Back-geared 18-inch Lathe: Flather & Co., Nashua, N. H. This lathe is double back-geared in ratios of 1 to 3.5 and 1 to 11.04; the speeds are in geometrical ratio, with an increment of 1.5 and range from 15 to 371 revolutions per minute. Gear ratios can be quickly changed and the back-gears are easily thrown in by a gear shift which controls either back-gear ratio.

Combination Holders: Eclipse Interchangeable Counterbore Co., Detroit, Mich. This tool is an Eclipse holder with an integral Wiard collet shank. As the holder is supplied with a knurled collar, it may be securely grasped when being placed in or removed from the chuck while the spindle is running. The holders are made in sizes to correspond with chuck sizes Nos. 0, 1, 2, and 3.

Sectional Steel Shelving: National Scale Co., 6 Mechanic St., Chicopee Falls, Mass. The shelving known as the "Multi-Unit" is designed to withstand long-continued severe use. All parts are interchangeable and can be had in plain steel or black or olive-green enamel. Although only the standard size, 36 by 12 by 12 inches, is made at present, a variety of sizes will soon be available.

Transformation-point Recording Apparatus: Leeds & Northrup, Philadelphia, Pa. With this apparatus, it is possible to locate accurately the transformation point of a steel while it is being heat-treated. The changes in temperature of both the steel test piece and of a piece of material which has no transformation point are recorded on a chart, and the transformation point is the place where the lines cross each other.

Two-pronged Electric Soldering Iron: Clemens Electrical Corporation, Buffalo, N. Y. With this iron the heat is generated by touching the object to be soldered, brazed, or annealed with the two high-resistance points of the iron; removing the iron from the work breaks the circuit. The heating points are made of solid brass and are held in position and separated by an asbestos bushing. From 6 to 5 volts only is required.

Vise-jaw Attachment: Universal Equalizer Co., Cincinnati, Ohio. This attachment is designed to hold pieces of any shape firmly in the vise. It is made of cold-rolled tempered steel in sizes that will fit any standard vise and consists of a number of lugs arranged with curved contacts in a channel. These lugs act as compensating wedges and force the grip lugs to protrude from the channel and equalize any pressure that may be applied.

Atlas Double Back-geared Lathe: Cleveland Lathe & Machinery Co., Cleveland, Ohio. The feed-rod and lead-screw drives of this machine are both reversing in the head. The apron has a separate reverse for feeds and the carriage has an indicating dial for thread cutting. The spindle is bored for No. 5 Morse taper shanks. The lathe has power cross-feeds and a positive quick-change drive feed shaft. There are eighteen available speeds.

Machine for Facing Shell Bases: Chandler & Farquhar Co., Boston, Mass. This machine, which was designed for rough-facing the bases of 6-inch shells, has a magazine in which four shells may be placed. This magazine is driven by a worm 33 inches in diameter to feed the shells over the tools. Hardened steel inserts hold the shells in the magazine while they are being faced. The tools are arranged on the cutter-head in three rows.

Locomotive-cylinder and Valve-chamber Boring Machine: Newton Machine Tool Works, Inc., Philadelphia, Pa. With this machine the cylinder and the cylindrical valve chamber in locomotive-cylinder castings may be bored at one setting. The spindle is 7 inches in diameter and it has a feed of 12 inches, by power or by handwheel. An attachment is provided for facing the cylinder heads, either when the cylinder is being bored or at some other time. There are six changes of feed.

Rivet Cutter: Rivet Cutting Gun Co., Cincinnati, Ohio. The manufacturer claims that with this machine 75 per cent of the cost of cutting rivets and bolts by hand will be saved; the machine may also be used for punching plates when the holes are afterward to be reamed to size. The machine consists of a cylinder in which is a piston mounted on slides. A cup-shaped casting at the lower end of the cylinder carries the cutting tool, the shank of which passes through the casting at the lower end of the cylinder.

Roller Lock-nut: Roller Lock Nut Co., New York City. The locking device of this nut is a steel roller which is held in place by a brass spring. This roller permits forward movement of the nut, but backward movement forces the roller into the threadway. The application of wrench pressure causes the roller to bite deeper into the threadway, but the movement of the nut causes the roller to drop into a recess in the side, so that the nut can be spun off by hand. It is claimed that the thread of the bolt is not injured in any way.

Heavy-duty Quick-change Lathe: Axelson Machine Co., Los Angeles, Cal. With this lathe only two levers are required to secure changes for cutting any of the thirty-two threads, which range from three to forty-six per inch; these changes can be made while the machine is running. The lathe is built in 16- and 18-inch sizes; the standard bed is 6 feet long, but other lengths up to 12 feet can be furnished. The spindle speeds of the larger lathe range from 12 to 349 revolutions per minute and for the smaller lathe from 6.67 to 420 revolutions per minute.

Miller with Oscillating Head: Superior Machine & Engineering Co., Detroit, Mich. This machine is especially suitable for milling small parts, and takes mills up to 3/8 inch in diameter. All parts are easily accessible and are protected from dirt and chips. The head is oscillated by a crank disk 2 1/2 inches in diameter, the pin of which works in a slot. The feed is operated by a pawl and ratchet and may be made as coarse as required for work of this kind. As both the pin in the crank disk and the spindle head are adjustable, there is considerable range in the length of the slot that may be cut.

Riveting Machine: Hanna Engineering Works, Chicago, Ill. This machine, which is sold by the Vulcan Engineering Sales Co., Chicago, uses a combination of toggles, levers, and guide links to give a gradual increase in the amount of pressure applied. The toggle action takes place while the piston is traveling through the first half of its stroke, during which time the die covers the greater part of its travel. The die completes its stroke while the piston travels through the remaining half of the cylinder. This slow movement of the die gives the metal in the rivet time to flow and fill the hole; besides, the rivet has a chance to set before the pressure is released on the return stroke of the die.

Duplex Turning Carriage: Amalgamated Machinery Corporation, Chicago, Ill. Although designed for use on shell-turning machines, this carriage will fit any lathe of sufficient strength and size. It consits of two tool-slides mounted on a single carriage driven by a single feed-screw. The radius-turning tool-slide is carried directly on the radius arm, the under side of which is recessed to form a seat for a large swivel bearing that fits over a male swivel seat on a free traveling lower slide. This device permits any form of tool to be used and to be set in any way, because it is always carried at the same position relative to the shell radius. With this device the operator gages his speed by the limits of the cutting tool used for the straight cut.

Gear-tooth Rounding Machine: Cross Gear & Engine Co., Detroit, Mich. This machine was designed for rounding the ends of the teeth of any sliding gears and will cut any degree of roundness on the end of a tooth, from simply taking off the edges to a full half circle. It will remove burrs from spur gears or bevel pinions quicker and more neatly than by filing, as well as sharp angular corners and burrs left on spiral gears by the hob. When desired, a bevel gear can be cut on one side of a tooth. The machine has rounded to a full half-circle all the teeth of a 133-tooth, 7-pitch, cast-iron flywheel in twelve minutes, and of a 17-tooth, 5-pitch, chrome-nickel, steel gear in two minutes. It will round the teeth of spur gear flywheels up to 30 inches in diameter and 12-inch face and with any number of teeth from 8 to 250, including odd numbers.

Rolls for Straightening 16-foot Plates: Hilles & Jones Co., Wilmington, Del. The rolls in this set are made of 0.55 per cent carbon open-hearth steel forgings. They have a finished diameter of 16 inches and are arranged in two tiers, three rolls in the upper and four in the lower. The rolls in the upper tier are spaced to alternate with those in the lower and are journaled in a single casting at each end. Each of these castings may be raised or lowered by means of two screws which are operated by a twenty-horsepower motor. The main driving gear is keyed to one of the inner rolls of the lower tier; the other rolls are driven by pinions meshing with idlers. These rolls are driven by a 125-horsepower motor. The two end rolls in the lower tier have a vertical adjustment of 1 inch, the device for which is operated by a fifteen-horsepower motor.

Automatic Polishing and Buffing Machine: Chase Turbine Mfg. Co., Orange, Mass. This machine can be used for polishing or buffing any circular or cylindrical work. The wheel-spindle is made to hold three wheels at one time, each wheel having a 2-inch face. This makes it possible to have a cutting, polishing, and coloring wheel on at the same time, with the result that when the work is mounted in the chuck the three wheels may be applied in succession, so that when the work is removed it is ready for the plater. The machine may have a vertical or a horizontal work-head. In either case, the work is held on an expanding chuck that is operated by a rod extending through a spindle in the head. Levers operated by a treadle force the expander out of the chuck body, so that the work may be put in or removed. At the same time, the clutch is released from the pulley, thus stopping the spindle. The work-head may be swiveled so as to bring the work into any position with relation to the wheels.

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NOTES ON LOCK MAKING

Locks are old and common devices for securing the safety of possessions. They were made by the Egyptians four thousand years ago, and until late in the nineteenth century were produced by hand work only. When they began to be made in large numbers the manufacture was long conducted on the plan of making the lock first and fitting the key to the lock, the same as the old hand lock-makers had done. The result was unsatisfactory, as much time and skill were required to fit the keys properly. Finally a genius reversed the process, made the key first and fitted the lock to the key. The reversed practice revolutionized lock making and helped to put it on a sound manufacturing basis.

The practice followed in the manufacture of Yale locks is to mill the steps in the key blanks on a special milling machine, which in a measure resembles a typewriter in having a number of finger keys. The lock keys are usually made in duplicate, and are milled simultaneously. The operator is furnished with a typewritten list for the lot of keys to be milled, and each finger key on the machine has a number; the list gives the combination desired to be milled in each pair of keys.

The keys are clamped in the machine vise and the designated finger keys are depressed and locked in position. The machine is then started and the lock keys are milled. They then go to the lock assemblers—generally girls. The girl picks up a lock barrel, pushes a key into the slot and then drops the required number of pins into the holes, using long and short pins, which are so selected that the tops of the pins stand approximately flush with the periphery of the barrel when supported by the key beneath, being then in the unlocked position. When the excess is filed off flush with a flat file, the barrel is ready to assemble in the lock which has corresponding pins and springs placed in position. These latter pins hold the barrel in the locked position when the key is out of the lock.

Another interesting phase of the manufacture of Yale locks is broaching the keyway in the barrel. The Yale locks are fitted with so-called paracentric keys—that is, keys having a cross-section of alternate grooves and ridges. The keyholes are broached on special vertical broaching machines, using broaches about six feet long. These broaches are made of paracentric cross-section, and finish a keyhole at one stroke, cutting on the downward stroke without feed. The effect of feed is produced by tapering the broach so that the teeth cut into the barrel progressively as the broach descends. The broaches virtually are vertical saws that cut their way into the barrel, making a paracentric path instead of the straight cut produced by the ordinary saw blade.

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MUNITION EXPERTS APPOINTED

The Council of National Defense has appointed a munition standards board composed of qualified experts in the manufacture of munitions, as follows: Frank A. Scott of the Warner & Swasey Co., Cleveland, Ohio; W. H. Vandervoort of Root & Vandervoort Engineering Co., East Moline, Ill.; E. A. Deeds of the Dayton Engineering Laboratories Co., Dayton, Ohio; Frank Pratt of the General Electric Co., Schenectady, N. Y.; Samuel Vauclain of the Baldwin Locomotive Works, Philadelphia, Pa.; and John E. Otterson of the Winchester Repeating Arms Co., New Haven, Conn.

USING MACHINES FOR DIFFERENT OPERATIONS

BY W. D. FORBES[1]

The standard machine tools that make up the equipment of machine shops carry with them certain presupposed mechanical operations. The lathe—the most useful of all tools—was developed with the idea of turning material on centers, in the chuck or on the faceplate. The planer has for its primary object the production of linear surfaces; so also have the shaper, slotter, and milling machines. The drilling machine was designed to rotate a drill, either feeding it into the work or feeding the work over the drill. The vertical boring mill is adapted for facing flat surfaces, boring cylinders, or finishing exteriors; while the horizontal type is designed more especially for boring cylinders and facing. But these machines are often used for other operations. For instance, a limited amount of milling can be done on the lathe by mounting a milling cutter on an arbor and clamping the work to the carriage. The horizontal boring mill can be conveniently and advantageously made to do the same class of work, especially those makes having power feeds provided in all directions. Milling machines can be used for boring and drilling.

These operations, however, may properly be called makeshifts, except in the case of horizontal boring mills provided with feeds. Makeshifts are generally uneconomical efforts, although they are often justified and necessary because of the lack of proper tools or because the proper tools are doing work that cannot be interrupted without producing more uneconomical conditions than the employment of the makeshift. To put it another way, the use of standard tools except for the purposes for which they were designed cannot properly be called economical manufacturing. An exception to this was brought to the writer's attention a short time ago by a manufacturer who used sensitive drilling machines as milling machines with most satisfactory results. He was making good deliveries on a large contract for war materials when an old customer brought to him a large number of small composition articles that required four narrow milled slots about 1/16 inch wide the entire length of the piece, which was 1½ inch, the depth of the cut being about 1/16 inch. These slots were placed 90 degrees apart, but exact spacing was not demanded. Between the four milled slots, and at right angles to them, four milled cuts of the same width had to be made and the cutter had to be sunk into the piece to a depth of ⅜ inch, producing a circular recess. The cutter had to be of such a diameter that when the last cut was made the longitudinal slots and the semicircular ones would be connected.

The manufacturer had no milling machines available for this work; and besides his milling machines were too large for such light milling. He was loath to sidetrack an old customer and inquiries among machine-tool men showed that it was impossible to obtain light milling machines, so he considered the possibility of doing the work on some other class of machine tool. The only available machines he could find were sensitive drilling machines. Now, a sensitive drilling machine is a light tool and hardly one that most persons would consider available for milling-machine work; yet this manufacturer saw that it was exactly the tool for this particular job, as the pieces that had to be milled were composition.

First of all, he made a special vise—small, of course—which was so designed that it would hold one of the composition pieces lengthwise at the end of the jaws and hold the piece vertically by semicircular recesses of the proper depth near the center of the vise. This vise was designed to rest in a dovetailed piece, in which it could be moved by means of a screw, and the base was bolted to the platen of the drilling machine. A milling cutter of the proper thickness and diameter was fitted to a taper shank arbor that fitted the spindle of the machine; of course, this cutter revolved in a horizontal plane. By means of proper stops in the vise jaws, the piece was clamped by its ends so that it overhung the edge of the vise; these stops were adjustable in order that the depth of the cut in the piece could be readily regulated both for the first cut and to accommodate the smaller diameter of the cutter after being ground. When the piece was clamped in the vise and the cutter started, the piece was fed horizontally past the cutter by means of the feed-screw. After the first cut was made, the piece was turned 90 degrees by bringing the milled slot to a mark on the top of the vise jaws. After the four straight milling cuts were made, the semicircular slots were milled by placing the piece vertically in the jaws in the recess. The four slots that were milled first were used for indexing for the position of the semicircular ones. Of course, a stop was provided to bring the piece to the same position each time, which would give the proper depth.

A careful study of this improvised milling arrangement proved that notwithstanding the fact that a hand feed had to be used, more rapid work was produced than was possible on the regular type of hand milling machines. Besides this drilling-milling machine cost less than half as much as a light milling machine, and subsequent use showed that in many ways this makeshift was really an economical manufacturing arrangement.

All machine-tool designers have in view the production of a tool that will function satisfactorily. This is, of course, the primary idea; the second is to design a tool that will meet as large a demand as possible. But it seems to the writer that machine-tool designers have been tied to certain ideas that result in putting on the market machine tools with too great a range of work and it would be advantageous to break away from these traditions or usages. A record of the length of cuts made on a universal milling machine used for jobbing shows that for over a year the cuts averaged slightly less than two inches, yet the machine was able to cover a surface of over five times this length. This record also showed that the vertical adjustment averaged less than ½ inch while there was a possible adjustment of over 8 inches on the machine. It must be remembered, however, that often a short milling cut has to be taken at one end of a shaft while a second, third or fourth cut must be taken on other parts of the shaft, which demands that the platen be moved several inches between the cuts. It is therefore evident that a machine having only a two-inch cut would not do for a jobbing machine.

There are, however, manufacturing propositions where it would undoubtedly be wise to change this system of wide possibilities to much narrower limits by producing milling machines, for instance, that are adapted only for the shorter cuts. This idea was forcibly brought to the writer's attention when he was shown a room full of milling machines that were making cuts as short as ⅛ inch and none longer than 1 inch; yet every one of these machines was able to mill many times these lengths and this range was known when they were bought. Had these machines been designed for special work, three machines could have been made from the material in each one. This would have materially reduced the cost of the plant besides resulting in quicker work and lessening the power required to run the machines. It would be a bold machine builder who would risk his money by placing on the market a milling machine with only, say, a 2½-inch travel of feed; and the purchasers of such machines would be few in number; yet when it comes to a manufacturing proposition, such special designs should have far more consideration than is now given to them.

Another illustration is the screw-cutting feature of a lathe. Usually, the lead-screw has sufficient length to cut a thread in any position between the centers, when farthest apart, or the entire length between centers. This demands a considerable outlay of money if the feed-screw is really well made, and about 80 per cent of the length of the lead-screw is doing nothing the majority of the time. Now, on lathes up to 16 inches swing, threads more than 6 inches long are rarely cut. Why not, therefore, design the lathe so that the lead-screw will be of sufficient length to cut a thread, say, 12 inches long and have this short lead-screw moving with the carriage so that it can cut the thread anywhere between its centers? This would reduce the cost and make for accuracy, as it is much easier to produce a short accurate lead-screw than a long one. We are constantly confronted with the high cost of production, and it seems manifestly absurd for manufacturing

[1]Address: 236 Homestead St., New London, Conn.

machines to be designed with the idea of doing anything more than a single operation. The case of a light sensitive drilling machine of low cost performing milling cuts that are usually done on high-priced milling machines seems to open up a line of thought in this direction.

* * *

THE MASTER CATALOGUE

One way to reduce the cost of buying and selling is to do away with the present system of making catalogues of all shapes and sizes and adopt a uniform size sheet for data sheets, price lists, catalogues, etc. When outlining the idea to the National Association of Purchasing Agents, W. L. Chandler, assistant treasurer of the Dodge Sales & Engineering Co., said that this plan would make the information more available and increase the value of the catalogues to the buyer. Much of the printed matter which is thrown into the waste basket yearly because the buyer has no place to file it would be kept for reference by the adoption of this plan. It was suggested that the details of this scheme, or "master" catalogue, be worked out by a board composed of representatives of national trade, engineering, and other associations, but the following plan was outlined.

The sheets should be 8½ inches by 11 inches in diameter so that they can be kept in standard vertical letter files; market reports and correspondence pertaining to the different price lists, such as quotations, discounts or letters giving weights, freight rates, and other data can be filed with the sheets to which they apply. To prevent the master catalogue from becoming obsolete, colored paper may be used. For example, say that in 1917 all sheets will be printed on white paper and will bear the date of issue, and in 1918 they will be printed on yellow paper while other colors will be used for 1919, 1920 and 1921. White will again be used in 1922 and the other colors repeated in regular order. Thus five colors will carry through the life of the catalogue. The seller will have a record to show that buyers have received white sheets, and during, say, December, 1921, he will notify them that such sheets are still in effect and entitled to remain in the catalogue if the buyer is still interested in such material. Upon such advice, the sheet will be stamped by the buyer "O. K. 1922" and left in the catalogue. During January, 1922, the buyer will remove from the catalogue all white sheets that have not received this stamp. If his interest in the material has ceased, the sheet will be destroyed; if his interest remains, he will notify the seller about such sheets as are open to doubt.

On classes of material for which data five years old is not dependable the sections of the catalogue known to contain this data may be revised as often as judgment dictates. The colored sheets lend the same help in a revision of any frequency. The use of this master catalogue will greatly reduce the waste circulation and expense of printing catalogues. It will not limit the quantity of the information contained on the sheets or in the books and will not in any way restrict advertising matter, except that which the seller desires to have the buyer retain in his file. The sheets or books may be printed from any plates used for bound catalogues and will give every opportunity for the proper treatment of the subjects involved. The catalogue may be printed on paper of a quality equal to that of any book now used for the purpose; the illustrations may be just as effective as desired; and the ink may be of any color to best present the goods. The only restriction will be as to the size of the sheets or books (thickness is not restricted) and the issuance of separate sheets or books where one seller might handle goods of more than one classification.

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The date of the spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio, has been changed from May 22-25 to May 21-24. A feature of the spring meeting will be a joint session on May 22 with the National Machine Tool Builders' Association. The session will be in charge of the Cincinnati local committee and a committee representing the National Machine Tool Builders' Association. Papers will be presented on employes' service work and industrial education as developed in Cincinnati.

CUTTING INTERNAL HELICAL GEARS ON THE FELLOWS GEAR SHAPER

BY REGINALD TRAUTSCHOLD[1]

On page 526 of the article "Internal Helical Gearing" which appeared in the February number of MACHINERY, a method of cutting internal helical teeth on the Fellows gear shaper is described, which calls for further explanation. The method described presupposes the employment of a regular Fellows gear shaper such as the No. 6 designed for spur gears, and necessitates inclining the work-arbor so that the reciprocating path of the cutter is in line with the gear teeth. This is not the method, however, by which helical gears are cut on the gear shaper; while theoretically a gear might be cut in this fashion, there are certain practical difficulties which thorough research makes plain. In order to complete the gear teeth properly with the work-spindle inclined at an angle coinciding with the helical angle of the gear to be cut, it would be necessary to move the blank axially on its work-spindle as it rotates. Otherwise the teeth would not be properly finished. The center distance of cutter and work would be at a minimum in only one position as the cutter moves up and down. It would be necessary to generate the teeth in all planes at this minimum position. From this it becomes obvious that the axial movement would be a necessity. As the maximum gear face which may be handled upon the gear shaper is 5 inches, it is evident that with 1/20 inch feed per rotation of the blank the work must be rotated 100 times to complete a gear of 5 inches, and in all probability the teeth would not be smoothly cut. Wavy feed lines might be in evidence.

The action of helical gears rotating on parallel axes is identical with that of spur gears. In the Fellows helical gear shaper the cutter is a helical gear provided with proper clearance. The axis of the cutter-spindle is parallel with the axis of the work-spindle. The cutter-spindle is provided with a helical guide of a lead corresponding to that of the cutter. As the cutter-spindle reciprocates, the guide imparts the necessary twisting motion to pass the cutter through the proper path for shaping the gear. The work is relieved on the return stroke by a slight movement of the apron which carries the work-spindle. The mechanism which performs this duty is identical with that of the standard spur gear machine. If a section were taken through the work and the cutter at right angles to the axes of the two, the outlines of two involute spur gears would appear, one being the cutter and the other the work. When the helix advance in a helical gear is slightly in excess of the circular pitch measured in the plane at right angles to the axis of the gear, all possible advantage of the helical gear has been obtained. Further increase is of no advantage and results in setting up undue endwise thrust. It has been ascertained that two helical angles, *viz.*, 15 degrees and 23 degrees, cover nearly all cases which may arise. The fact that helical teeth are much stronger in action than spur teeth permits the use of finer pitches with the corresponding decrease in helical angle. For this reason it is usually possible to so design the gears that the helical angle falls within the scope of those mentioned above, which are the standards laid down. When a special case arises which cannot be covered by the guides and cutters as standardized, special cutters and guides are furnished.

* * *

CHANGE OF DATE OF SPRINGFIELD EXPOSITION

The date of the industrial exposition and export conference to be held in Springfield, Mass., has been changed from May 26-June 2, to June 23-30, in order to meet the wishes of a number of manufacturers who require more time to make ready their exhibits. F. H. Page, president of the National Equipment Co., has been made chairman of a general committee representative of a wide variety of American business interests, which is planning a series of small meetings in manufacturing centers to acquaint the trades generally with the opportunity to reach a great home market as well as to cooperate for a united front in the foreign field. John C. Simpson is general manager of the exposition.

[1]Address: 39 Charles St., New York City.

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PRODUCTIVE CAPACITY A MEASURE OF VALUE OF AN INDUSTRIAL PLANT

BY H. L. GANTT[1]

If there is any one thing which has been made clear by the war, it is that the most important asset which either a man or a nation can have is the ability to do things. The recognition of this fact is having a far-reaching effect, and makes clear that the real assets of a nation are properly equipped industries and men trained to operate them efficiently. The money that has been spent on an industrial property and the amount of money needed to reproduce it are both secondary in importance to the ability of the plant to accomplish the object for which it was constructed.

To determine the value of an industrial property, it is necessary to know the cost at which the plant can produce its product as well as the amount produced. While there are many methods of cost accounting, they are based mostly on one of two propositions: (1) The cost of an article must include all the expense incurred in producing it, whether such expense actually contributed to the desired end or not; (2) the cost of an article should include only those expenses actually needed for its production, and any other expense incurred by the producers must be charged to some other account.

By the first proposition, the expense of maintaining in idleness any part of a plant is charged to the cost of the product made in the part of the plant that is in operation; by the second, the expense is deducted from the profits. When plants are operated at full capacity, both plans give the same cost. When they are operated at less than full capacity, the expense of carrying the idle machinery makes the cost of the product greater; while by the second plan, the cost remains constant. It is most interesting to note that when costs are figured by the second plan, an immediate effort is made to determine why the machinery is idle and to put it in operation. It is realized at once that this machinery should be operated even if only a part of the expense of maintaining it is earned.

In many large plants charts that show the idle time of the machines and the reasons for this idleness are prepared each month; they have already had an educational influence on the managers of those plants, as they make it possible to contrast the efficiency of the management with that of the workmen. They show that idle machinery which cannot be used should be disposed of, and the money received and the space occupied put to some useful purpose. Simple ownership of a machine costs money, inasmuch as it takes away from available assets. For instance, if a machine is bought for $1000, the firm loses the interest on that sum, say at 5 per cent per year, and must pay taxes on the machine at, say, 2 per cent, and an insurance of 1 per cent. Further, the machine probably depreciates at the rate of 20 per cent per year, and $50 or more per year must be paid as rent for the space it occupies. All these expenses, together amounting to $330, go on whether the machine is used or not. So the simple fact of having bought this machine and kept it takes from the available assets approximately one dollar per day.

If the cause for idleness is ascertained each day, it is possible to find the expense of each cause of idleness as shown by the chart. However, no conclusions should be based on the figures for one month, but on the results of a series of months during which the problem has been carefully studied. That idleness which is due to lack of orders shows that the selling policy is wrong or that the plant is larger than it should be. If it is due to lack of help, the labor policy needs investigation. If it is due to lack of material or poor material, there is inefficiency in the purchasing policy and the storekeeping system. While such a chart will not give a measure of the efficiency with which these functions are performed, it does give an indication of that efficiency. In several cases where such charts have been gotten out, they have resulted in the scrapping of machinery that had been idle for years; the space thus made available was then put to more useful purposes. In one case, this chart resulted in the renting of temporarily idle machinery at a rate which went far toward covering the expense of carrying that machinery.

Under the first system of cost accounting, the facts brought out by this method are not available, and the increased cost that a reduced output must bear is a great source of confusion to the salesman. The second system with its constant costs shows that non-producing machinery is a handicap to the industry, just as workmen who do not serve some useful purpose in a plant or industry are a handicap to the plant or industry.

Another factor that enters into the value of a "going plant" is the organization. The value of an organization lies not so much in the personality of the manager or leader (who may die or go elsewhere) as in the permanent results of his training and methods, which should go on with the business, and are therefore an asset and not an accident. Andrew Carnegie has said that his organizations were of more value to him than his plants.

[1]Abstract of a paper presented at the annual meeting of the American Society of Mechanical Engineers, December, 1916.

* * *

THE JOHN ERICSSON MONUMENT

Last fall Congress appropriated $35,000 for the erection of a monument in Washington to the memory of John Ericsson, as noted in the October number of MACHINERY. A special commission was appointed by the government to take care of the details in connection with the erection of the monument. This commission met at Chicago, March 10, and it was decided that $25,000 was needed, in addition to the appropriation made by the government, to erect a fitting memorial. It is proposed to raise this amount by private subscription, and all American engineers, organizations and societies are invited to aid in commemorating John Ericsson, who rendered signal service to the country at a time when its very existence hung in the balance. It is the first time that the United States government has made an appropriation for the erection of a monument to an engineer, and engineers generally will no doubt be proud to aid in the efforts of the John Ericsson Monument Commission. Subscriptions toward the monument will be received by Erik Oberg, associate editor of MACHINERY, 148 Lafayette St., New York City, who is a member of the commission, and will be acknowledged by publication as directed by the commission.

* * *

AMERICAN MUSEUM OF SAFETY AWARDS

The jury of award of the American Museum of Safety, New York City, has announced the award of four of the five gold medals given annually for noteworthy achievements in safety work. The E. H. Harriman memorial medal, which is given annually to the American steam railroad that has been most successful in protecting the lives and health of its employes and of the public, has not yet been awarded. The Anthony N. Brady memorial medal has been awarded to the Connecticut Co., with headquarters at New Haven, Conn. The *Scientific American* medal was awarded to the Pullman Co. for originating the Dean end-frame for passenger cars. The Louis Livingston Seaman medal has been given to the Julius King Optical Co. of New York City; and the Travelers Insurance Co.'s medal to the Commonwealth Steel Co. of St. Louis, Mo., for its safety system and protective devices.

* * *

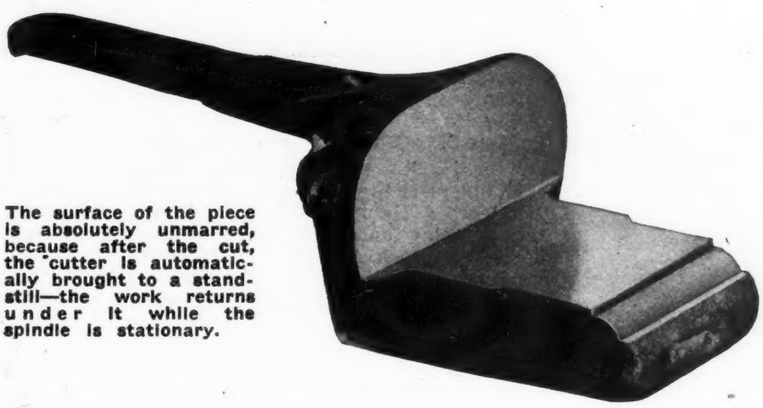
Recently an accident occurred to one of the machines in the plant of Samuel W. Moore & Sons, Inc., Newark, N. J., which brought out a most interesting point concerning the bearings. The machine in question is a special paraffining machine used in the manufacture of paraffined paper containers. The top shaft was accidentally hit and bent to an angle of ten degrees. When the accident occurred it was feared that a new shaft would have to be substituted immediately, thus causing a tie-up of the whole plant for two days while the repair was made. But on investigation the machine was found to be still in good running order. The bent shaft was mounted on S. K. F. self-aligning ball bearings and they carried it without binding, because the self-aligning feature compensated for the bend.

CINCINNATI AUTOMATIC MILLERS

With Intermittent Feed and Automatic Spindle Stop For Manufacturing

RIFLE AND MACHINE GUN COMPONENTS

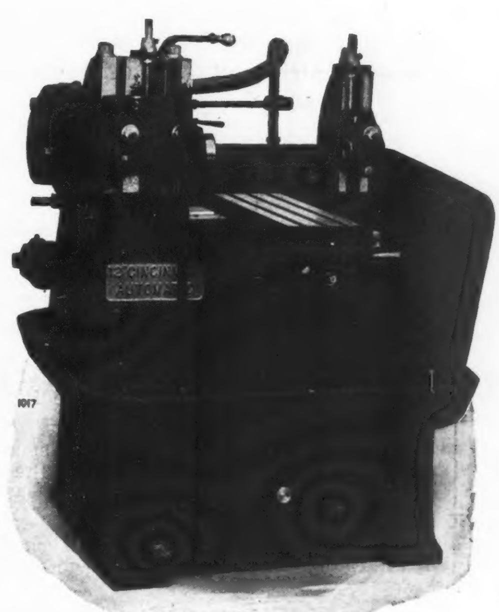
and Similar Parts in Quantities



The surface of the piece is absolutely unmarred, because after the cut, the cutter is automatically brought to a standstill—the work returns under it while the spindle is stationary.

They have the intermittent feeding feature, which has proven so successful on our earlier machines, with this addition — after the cut is taken the spindle is stopped automatically so that the work returns beneath it while the cutter is stationary—no danger of marring the surface of the work because of a revolving cutter.

Consider, too, the advantage of this from the standpoint of safety. The operator removes the finished piece and chucks a new one while the cutter is stationary. He can't get caught by a swiftly revolving although idle cutter. After he chucks the new piece, he moves one lever—and immediately both the spindle and feed movements start again.



This is one improvement on the Cincinnati Automatic. There are others equally vital. Do you wonder this new machine has already made a place for itself in the esteem of a number of big munitions shops?

For manufacturing parts in quantities it offers exceptional advantages.

Bulletin containing details will be sent you upon request.

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI, OHIO

DETROIT PLANT OF PARKER RUST-PROOF CO.

Parker Rust-Proof Co. of America is erecting a large plant in Detroit, Mich., for the rust-proofing of steel and iron parts. The company has secured the patent rights to a number of rust-proofing processes, including the Coslettizing process, and is doing work for the motor car companies in rust-proofing parts. The new plant will cover four and a half acres, and plans have been made for erecting branch plants in all the principal industrial cities. The rust-proofing process employed makes use of chemicals having an affinity for steel and produces a black oxide on the surface which is virtually an integral part of the metal. Hence it is permanent, as a thin film of the metal itself has been changed. In this respect it differs from paint or enamel, which only serves to exclude the atmosphere, but does not necessarily prevent slow rust in the metal beneath.

* * *

NEW RUSSIAN MACHINERY CORPORATION

A large corporation has been organized in Petrograd, Russia, by well-known financiers and engineers to build a full line of small tools, machine tools and wood-working machinery which do not conflict with the lines of American machinery now handled by the M. Mett Engineering Co. The officers of the corporation are A. E. Putilov, president; M. A. Mett, managing director; and L. S. Neuschul, financing director. The latter is well known among American machinery manufacturers, having spent considerable time in the United States in the past two years, during which he purchased several million dollars' worth of machinery for export to Russia. The company has been organized with a large paid-up capital, and has acquired the plants of Fillipov Bros. and Dangayer & Kayser, near Moscow, at a cost of 15,000,000 rubles. The temporary New York office is at the Hotel Vanderbilt, J. M. Wimpfe acting as representative.

* * *

HIGH FREIGHT RATES

Ocean freight rates and their effect upon American business have been cited in some striking instances. The freight charges to the Straits Settlements on a hundred or so iron beds invoiced in the United States at $339 were $686; though this place is half way around the world, it is not exactly off the routes of trade. The combined freight and insurance charges to South Africa of a shipment of glassware, which had a value of $526 F. O. B. New York, was $534. To get $1300 worth of nails to South Africa cost $600. Of course, times are abnormal, and so are ocean freight rates.

PERSONALS

Albert A. Dowd, consulting mechanical engineer, has withdrawn from "The Consultants" at 101 Park Ave., New York City.

Carl A. Smarling was made superintendent of the Rider-Ericsson Engine Co., at Walden, N. Y., following the recent reorganization.

George Smart, for the past twelve years editor of the *Iron Trade Review*, Cleveland, Ohio, has joined the editorial staff of the *Iron Age*.

H. B. Ibsen has severed his connection with Wismach & Co. and is now manufacturing reference gages under the name of Ibsen & Co., P.O. Box 572, Milwaukee, Wis.

Cass L. Kennicott, a well-known water softener expert, has associated himself with the Permutit Co., New York City, and has been put in charge of the company's Chicago office, 208 S. La Salle St.

M. C. M. Hatch, superintendent of fuel service of the Delaware, Lackawanna & Western Railroad, has resigned to take the position of assistant to the president of the Locomotive Pulverized Fuel Co., of New York City.

W. E. Wolfram, for the past eleven years superintendent of the projectile department of the Bethlehem Steel Co., South Bethlehem, Pa., has resigned. Mr. Wolfram intends to make an extended trip to the Pacific coast.

E. P. Dillon, formerly assistant to the manager of the railway and lighting department of the Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has been appointed manager of the power division of the New York office.

E. D. Kilburn, manager of the power department of the New York office of the Westinghouse Electric & Mfg. Co., has been appointed district manager to succeed W. S. Rugg, who has been made manager of the railway department.

Robert L. Arms, for several years connected with the sales department of Manning, Maxwell & Moore, Inc., has associated himself with Sherritt & Stoer Co., Inc., 603-604 Finance Bldg., Philadelphia, Pa., as assistant to the general manager.

W. S. Rugg, formerly district manager of the New York office of the Westinghouse Electric & Mfg. Co., has been appointed manager of the railway department, succeeding C. S. Cook. Mr. Rugg's headquarters will be at East Pittsburg, Pa.

Thomas P. Bradshaw, mechanical engineer, has resigned from the staff of the American Museum of Safety, New York City, to enter the position of mechanical safety engineer with the American Smelting & Refining Co., 120 Broadway, New York City.

L. K. Berry, district manager of New York for the Warner & Swasey Co., Cleveland, Ohio, has been appointed assistant sales manager with headquarters in Cleveland. Eugene R. Gardner becomes district manager for New York, assisted by R. L. Glaser.

Leon P. Alford, editor-in-chief of the *American Machinist* for nearly six years has resigned and has taken the position of chief-of-staff of *Industrial Management*, formerly the *Engineering Magazine*. John A. Van Deventer, managing editor of the *American Machinist*, has been made editor-in-chief.

William H. Reece, of Florence, Mass., for twenty years superintendent of the Northampton Emery Wheel Co., and also of the Reece & Hamman Co., has taken a position in charge of the grinding and polishing machine department of the Noble & Westbrook Mfg. Co., Hartford, Conn. The company is building a full line of grinding and polishing machinery.

Harrison W. Craver, chief librarian of the Carnegie Library in Pittsburg, Pa., since 1908, has resigned to take the position of director of the library of the United Engineering Societies, 29 W. 39th St., New York City. Mr. Craver's new position will put him in charge of what is believed to be the largest engineering library in the world, with approximately 150,000 volumes on its shelves.

Alfred H. Bartsch, for seven years advertising manager of the Bosch Magneto Co., has resigned to become a member of the firm of McLain-Hadden-Simpers Co., advertising and merchandising council, of Philadelphia and New York City. Robert S. Westcott, who has been assistant advertising manager of the Bosch Magneto Co. for the past seven years, has assumed the duties of advertising manager in the company's advertising offices at 1764 Broadway, New York City.

G. K. Atkinson has joined the organization of the Wood Turret Machine Co., Brazil, Ind., as chief engineer. During the past two years, Mr. Atkinson was associated in an executive capacity with the Cincinnati Planer Co., and prior to that connection was with the Steinle Turret Machine Co. He organized and was president of the Modern Machine Tool Co., of Cincinnati, manufacturer of turret machines, since acquired by Greenlee Bros. & Co., of Rockford, Ill.

Edward P. Hughes, for ten years district sales manager of the Cataract Refining & Mfg. Co., Buffalo, N. Y., manufacturer of lubricating oils and cutting compounds, has resigned the position to become sales manager for the Detroit Soluble Oil Co., Detroit, Mich. Mr. Hughes has had years of valuable experience in handling lubricating and cutting oils, having been three years with the Standard Oil Co., prior to his long connection with the Cataract Refining & Mfg. Co.

George Schow, consulting director of the Northern Engineering & Trading Co., Christiania, Norway, is on a business trip in the United States seeking representation for a few more lines, including electrical machinery, sewing machine motors and other household electrical goods. Norway and Sweden offer a great market for electrical household devices because of the low cost of electric power; Russia also offers a market for these devices. Mr. Schow's address while here is 2955 Logan Blvd., Chicago, Ill.

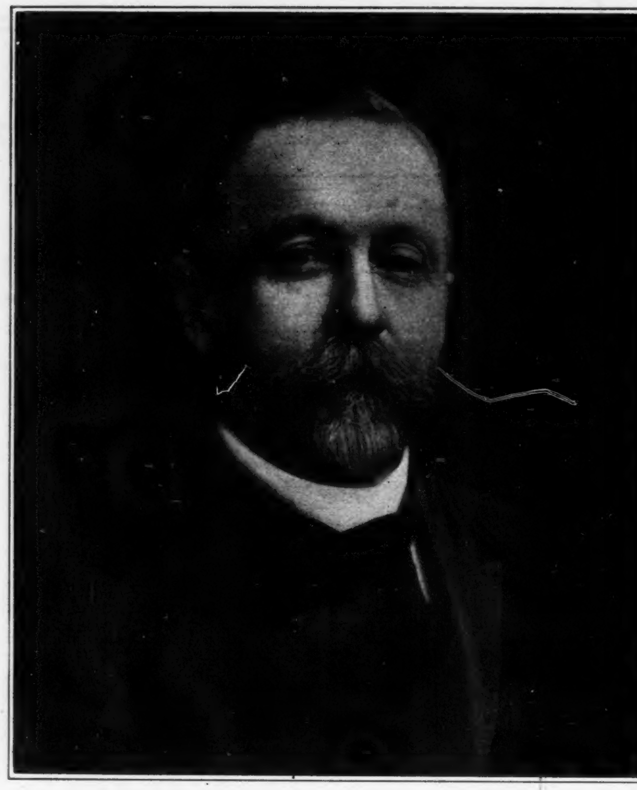
OBITUARIES

S. E. Weir, superintendent of the American Blower Co., Detroit, Mich., died February 13.

Albert Clark Stebbins, a vice-president of the Niles-Bement-Pond Co., 111 Broadway, New York City, died February 28 at his home in Plainfield, N. J., aged seventy-three years. He was born in the town of Monson, Mass. In 1865 he became an apprentice in the machine shop of Lucius W. Pond, Worcester, Mass. He continued as a machinist in this shop until about 1870, when he was appointed New York representative of L. W. Pond, with an office on Liberty St. About 1875, when the Pond business passed into the hands of David W. Pond, son

of Lucius W., Mr. Stebbins returned to the Worcester shop in the capacity of superintendent. In 1887 the shop at Worcester was taken over by the Pond Machine Tool Co., of Plainfield, N. J., and the shop equipment was moved to new buildings in Plainfield. Mr. Stebbins went to the Plainfield works as vice-president and general manager, and directed the construction and equipment of the new shops. He continued in this capacity until the organization of the Niles-Bement-Pond Co., when he was elected vice-president of this company and local manager of the Pond works. Mr. Stebbins left no children; his wife died in 1902. He served a term as member of the city council of Plainfield and at the time of his death was vice-president of the Dime Savings Bank of that city.

FREDERICK E. REED



Frederick E. Reed

Frederick E. Reed, whose death on February 18 was briefly noted in the March number, was born in Croydon, N. H. Mr. Reed's parents moved to Worcester when he was young, and he was first employed in 1870 as a bookkeeper for the Wood & Light Machine Co. of Worcester, where his father, John Reed, also was employed. Later he became chief draftsman for the company, and in 1875 he bought the interest of Vernon Prentice in the firm of A. F. Prentice & Co. of Worcester. Mr. Reed early realized the need of a better education, and after having spent two years in the shop, he took a course in Worcester Academy and at Howe's Business College, and studied drawing at the evening school provided by the Worcester County Mechanics Association. He became sole proprietor of A. F. Prentice & Co., after two years' connection, and the name was changed to F. E. Reed in 1877. This firm name was retained until 1890, when John R. Back, who had been the shop superintendent for years, became financially interested and the name was changed to F. E. Reed & Co., and to F. E. Reed Co. in 1894. Mr. Reed organized the Reed-Curtis Machine Screw Co. and the Reed Foundry Co., and was interested in the Mathews Mfg. Co. and the Worcester Lawn Mower Co. He was second president of the Worcester Branch of the National Metal Trades Association, and had been a director of the First National Bank of Worcester. He was a vice-president of the National Machine Tool Builders' Association and later treasurer. He retired in 1912 when he sold his business to the Reed-Prentice Co. for $1,250,000 in cash.

Mr. Reed's success in the machine tool field may be attributed to his thorough and far-seeing business ability, and to his even and courteous treatment of everyone with whom he came in contact. His thoroughness showed itself in his machines, in the refinement of little features that are often neglected or overlooked. When he laid the foundations for his first shop, the same thoroughness showed itself in the planning. In his early days as a machine shop owner, Mr. Reed had hard work to make both ends meet. In panic times in the late seventies, he had but six or eight men at work, and sometimes only one (J. E. Snyder) besides himself. Times were so hard that many weeks the single men had to wait for their wages, but they always got them, and it was a well-known fact that his word was as good as his bond. In his accounting, Mr. Reed was also thorough. When he started, he was his own bookkeeper, and it is said that the books of the concern were a remarkably fine example of accounting. For this reason he knew just where he was, at all times, on costs of manufacture and selling and was able to operate on a very close margin when necessary. The overhead expenses were extremely low and the organization had no non-producers. At the outset, Mr. Reed did his own designing. He was an excellent draftsman, and the same attention to details made his work in designing as good as his shop management. He was a firm believer in the policy of keeping up production of machine tools in dull times, and often accumulated large stocks by building persistently when there was little or no market. His foresight was always rewarded when the demand again developed, being then in a position to supply his customers when other makers were struggling to repair their shattered shop organizations and to mend the gaps made in their selling force.

COMING EVENTS

April 23-26.—Annual convention of the National Metal Trades Association in New York City; Hotel Astor, headquarters. Homer D. Sayre, secretary, Peoples Gas Bldg., Chicago, Ill.

April 26.—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

May 21-22.—Spring convention of the National Machine Tool Builders' Association in Cincinnati, Ohio. Charles E. Hildreth, general manager, Worcester, Mass.

May 21-24.—Spring meeting of the American Society of Mechanical Engineers in Cincinnati, Ohio. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

June 13-15.—Annual convention American Railway Master Mechanics' Association at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 13-20.—Annual meeting of the Railway Supply Manufacturers' Association at Atlantic City, N. J., in connection with A. R. M. M. and M. C. B. Associations' conventions. J. D. Conway, secretary and treasurer, 2136 Oliver Bldg., Pittsburg, Pa.

June 18-20.—Master Car Builders' Association's convention at Atlantic City, N. J. J. W. Taylor, Karpen Bldg., Chicago, Ill., secretary.

June 23-30.—Industrial exposition and export conference at Springfield, Mass. John C. Simpson, general manager.

August 30-September 1.—Ninth annual convention of the American Railway Tool Foreman's Association, Chicago, Ill.; Sherman Hotel, headquarters. C. N. Thulin, secretary-treasurer, 935 Peoples Gas Bldg., Chicago, Ill.

September 10-15.—Annual convention of the National Safety Council, New York City; Hotel Astor, headquarters. Marcus A. Dow, president, Grand Central Station, New York City.

September 10-15.—Exposition of safety appliances at the Grand Central Palace, New York City, under the auspices of the American Musuem of Safety, 18 W. 24th St., New York City. Arthur H. Young, director.

SOCIETIES, SCHOOLS AND COLLEGES

Delaware College, Newark, Del. Catalogue 1916-1917, with announcements for 1917-1918.

Grove City College, Grove City, Pa. Catalogue for 1916-1917 with calendar and courses of study for 1916-1917.

Lowell Textile School, Lowell, Mass. Quarterly bulletin containing annual report of the trustees for the year ended June 30, 1916.

Polytechnic Institute of Brooklyn, Livingston and Court Sts., Brooklyn, N. Y. Catalogue 1917-1918, with calendar and outline of courses.

School of Mines and Metallurgy, University of Missouri, Rolla, Mo. Bulletin for January, 1917, containing an article on "Road Problems in the Ozarks," by Elmo G. Harris, with a list of publications on rural roads compiled by Harold L. Wheeler.

New England Association of Commercial Engineers, 53 Devonshire St., Boston, Mass. Business directory of members for 1917. Those who manufacture, sell, or are in any way connected with concerns that manufacture or sell machinery or supplies used by lighting, railway or power plants, are eligible for membership.

Barber-Colman Association, Rockford, Ill., has just published a typographical work of art called "Knots," 9 by 12 inches, containing 168 pages of text and illustrations. "Knots" is to be a yearly publication that will be issued in the interest of co-operation and good will between the Barber-Colman Co. and its employes. The title was selected because of its emblematic qualities and because the tying of knots in yarn mechanically had an important influence in the development of the Barber-Colman Co. The business was founded principally on the hand knotter and warp-tying machine used in textile mills for tying broken warp. From this small beginning was developed the Barber-Colman power warp-tying machine for mechanically tying the threads or ends of new warp to the corresponding end of an old warp, thereby saving much time and labor compared with hand tying. The manufacture of milling cutters was taken up in 1908, and gear-hobbing machines in 1910. The book is profusely illustrated with halftones showing the plant, departments, personnel of the working forces, and the branch offices in various cities. Much space is given to sports and athletic events which have been popular features of the annual outings of the employes' association.

NEW BOOKS AND PAMPHLETS

Combustion in the Fuel Bed of Hand-fired Furnaces. By Henry Kreisinger, F. K. Ovitz and C. E. Augustine. 76 pages, 6 by 9 inches; illustrated. Published by the Department of the Interior, Bureau of Mines, as Technical Paper 137.

Traveling Engineers' Association—Proceedings of the Twenty-fourth Annual Convention. 414 pages, 5½ by 8½ inches; illustrated. Published by the Association, W. O. Thompson, secretary, N. Y. C. R. R., Cleveland, Ohio.

The Cooperative System of Education. By Clyde W. Park. 48 pages, 6 by 9 inches; illustrated. Published by the Department of the Interior, Bureau of Education, Washington, D. C., as Bulletin No. 37.

This pamphlet gives an account of the co-operative educational system developed in the College of Engineering, University of Cincinnati, Cincinnati, Ohio.

Resistance of an Oil to Emulsification. By Winslow H. Herschel. 37 pages, 6 by 9 inches; eight illustrations. Published by the Department of Commerce, Washington, D. C., as Technologic Paper of the Bureau of Standards No. 86.

When oil is used over and over, as is the usual practice in power plants, it may emulsify in a few days if not of good quality and have to be thrown away, because it will not pass through the filters.

A laboratory test has been devised by means of which it can be predicted, whether or not the oil will give satisfactory service. The test consists of violently stirring a small sample of the oil with water under standard conditions. By the use of the test described any power plant engineer can keep track of the deterioration of the oil, and thus learn when it is time to clean out the lubricating system.

Lettering for Draftsmen, Engineers and Students. By Charles W. Reinhardt. 54 pages, 7¾ by 10⅝ inches; 75 illustrations and plates. Published by the D. Van Nostrand Co., New York City. Price, $1 net.

This practical system of freehand lettering for working drawings has had an unusual sale, and now appears in the fourteenth edition, revised and enlarged. The new edition contains the analyzed Greek alphabet, showing various methods of laying out and constructing titles, as well as practice sheets. The book is one that we heartily commend to all draftsmen needing knowledge of better styles in lettering, and that means many. It treats of inclined lettering, upright lettering, freehand lettering applied to working drawings, various freehand alphabets, including the Greek alphabet, lettering of titles, lettering for photo-reproduction, etc.

Export Trade Directory. 536 pages, 6 by 9 inches nearly. Published by the "American Exporter," 17 Battery Place, New York City. Price, $5.

The new edition of the Export Trade Directory just published, comprises 536 pages, as contrasted with only 369 pages in the fourth edition. The directory has kept pace with the increase of the foreign business of the United States and now includes over 2000 firms, of which 1295 are New York export houses. The directory also includes lists of value to every exporter, such as, for example, the large banking houses making a specialty of dealing in foreign exchanges, buying manufacturers' drafts, etc. The new work contains an extension of the lists of foreign trade forwarding agents, including concerns of this character in other cities than New York. Specifications of shipping routes to foreign markets, locations of American consuls abroad and foreign consuls in the United States are also features of value to those interested in developing their foreign trade.

NEW CATALOGUES AND CIRCULARS

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City. Bulletin 41514 of single-phase variable-speed motors.

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City. Pamphlet of Sprague direct- and alternating-current electric fans.

Buda Co., Chicago, Ill. Catalogue containing dimensions and specifications of the four types of electric industrial trucks manufactured by this company.

Medina Machine Co., Medina, Ohio. Circular of the Medina vertical drilling and boring machine, with constant-speed drive, four power feeds, and a speed-box containing hardened change-gears.

American Laundry Machinery Co., Norwood Station, Cincinnati, Ohio. Circular illustrating equipment for washing or reclaiming wiping rags. It is claimed that an appreciable saving is effected by the use of this equipment.

Fiske Bros. Refining Co., 24 State St., New York City. Pamphlet treating of "Climax" mineral lard oil, which is applicable for use on all classes of cutting operations. It can be used straight or as a base for many cutting oils.

Hess & Son, 1031-1033 Chestnut St., Philadelphia, Pa. Circular on "Epicassit," a metallic protective coating for metal articles or structures of all kinds, being a metal powder which is mixed with a liquid and applied with a brush, and then melted by any convenient source of heat.

Universal Equalizer Co., Bell Block, Cincinnati, Ohio. Circular of the "Universal" equalizing vise jaw attachment for gripping irregular shapes. The attachment may be applied to any machinist's vise, and with it in place irregular, tapered, round and other shapes can be held firmly.

Southwark Foundry & Machine Co., Philadelphia, Pa. Catalogue of leather packings, valves, shock absorbers, forging presses, punching and shearing presses, flanging presses, extrusion presses, hydraulic accumulators, hydraulic riveters, hydrostatic wheel presses, and other hydraulic machinery and fittings.

Hy-grade Machine Co., 5606 Curtis Ave., Cleveland, Ohio. Circular of the "Hy-grade" cylinder grinder for grinding the bore of engine cylinders. It has a working space under the machine of 18 by 22 inches, and a grinding spindle 16 inches long, which gives ample capacity for handling the general run of work.

Charles H. Walker, 1565 W. Grand Boulevard, Detroit, Mich. Circular descriptive of the "Cross" gear-tooth rounding machine, especially designed for rounding the ends of sliding meshing gears, such as automobile transmission gears, automobile flywheels, and gears of this kind used in machine tools and other machinery.

Independent Pneumatic Tool Co., Chicago, Ill. Catalogue 10, illustrating and describing pneumatic tools and electric drills. Dimensions of the various tools are given, as well as information on the care and operation. This catalogue shows a new line of piston air drills equipped with pressed vanadium steel connecting-rods and pistons.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa. Catalogue entitled "Ball Bearings in Machine Tools," illustrating various types of machine tools equipped with Hess-Bright annular ball bearings. The catalogue treats of the uses of Hess-Bright ball bearings, special features, and results obtained by their application.

Boston Gear Works, Norfolk Downs, Mass. Catalogue F-7 of gears, racks, sprockets, chains, bearings, universal joints, worms, worm-wheels, ratchets, etc. The Boston Gear Works was established in Boston in 1891 and removed to Norfolk Downs in 1906. The main building contains 29,000 square feet of floor space, and the total floor space available is about 37,000 square feet. The plant is fully equipped for handling all kinds of gear work.

Prentiss Vise Co., 110 Lafayette St., New York City. Catalogue of Prentiss vises, which is the fiftieth illustrated price list of vises issued by the company. The catalogue contains information on the use and abuse of a vise and describes the mechanism of the Prentiss self-adjusting jaw vise. The various parts of the vises are illustrated and the names used to designate them are given, for convenience in ordering repair parts.

Hetherington McCabe Co., Piqua, Ohio. Circular descriptive of the "Brandenburg" self-lubricating emery wheel dresser. This tool has a steel spindle and a cast-iron bearing lubricated with flake graphite, which fills the pores and makes the bearing practically frictionless. This frictionless bearing permits the immediate spinning of the cutters when placed against the emery wheel, so that they dress and true the wheel instantly without the points of the cutter wheels being ground off.

W. S. Barstow & Co., Inc., 50 Pine St., New York City. Catalogue entitled "The Puzzle of Prosperity and Its Solution," treating of the question of increasing production to keep pace with the growing demand for manufactured products, by (1) building new plants; (2) enlarging existing ones; and (3) scientifically rearranging machinery, equipment and processes so that production may be increased without materially adding to the investment. The book contains views of bridges, trestles, industrial plants, etc., built by this company.

Ingersoll-Rand Co., 11 Broadway, New York City. Form 3037, covering the straight-line type of dry vacuum pump. Form 3038, treating of the duplex type of dry vacuum pump. Both types of machines are equipped with Ingersoll-Rogler valves, are capable of maintaining a high vacuum, and will handle discharge pressures of several pounds. The maximum degree of vacuum possible varies in the different machines to within 0.6 inch of the barometer. These vacuum pumps are made in steam- and power-driven types, in a large range of sizes and capacities.

American Pulley Co., 4208-60 Wissahickon Ave., Philadelphia, Pa. Pamphlet entitled "Building No. 25," containing illustrations of a building recently erected by the company for the purpose of safeguarding the health of its employes and for their comfort and convenience. On the first floor is the health officer's room, where his records are kept and reports prepared. The first-aid room is also located on this floor. On the second floor are steel lockers, wash basins, and shower baths. There is also a roof garden, part of which is enclosed for use in bad weather.

Parker Rust-proof Co. of America, Detroit, Mich. Catalogue descriptive of the Parker process of rust-proofing iron and steel. This process will not increase or decrease the size or contour of an article. For example, in rust-proofing screws, the pitch is in no way affected. Machined parts, links and mechanical appliances completely assembled can be treated without affecting their operation. The book illustrates a large number of articles that can be successfully treated by this process, among which are flexible conduit, fans, pinions, shock absorbers, cylinders and miscellaneous motor parts, axles, wheels, twist drills, taps and reamers, chains, furnace registers, balconies, stair rails and metallic window sash, cabinet and builders' hardware, metallic office furniture and equipment, screw machine products, wire mesh screens, steam fittings, cash registers, typewriters, etc. The Parker process forms an excellent base for parts that are subsequently to be japanned, enameled or painted. Bright nickeled parts can also be subjected to the process, and parts formerly made of brass can be made of cast iron, by rust-proofing and brass-plating.

TRADE NOTES

Standard Mfg. Co., Bridgeport, Conn., has changed its name to Bilton Machine Tool Co.

Worcester Lathe Co., Worcester, Mass., has moved from 134 Gold St. to 68 Prescott St.

Oliver Instrument Co., 1168 Cass Ave., Detroit, Mich., has moved its factory to Adrian, Mich.

D. & W. Machine Co., Inc., New York City, has moved its offices from 149 Broadway to 1472 Broadway.

Master Machine Works, 110-112 W. 40th St., New York City, has changed its name to Master Machine Tool Co.

Steinle Turret Machine Co., Madison, Wis., manufacturer of Steinle turret lathes, has completed a fine office building and some additions to the plant to increase the manufacturing facilities.

De Laval Steam Turbine Co., Trenton, N. J., manufacturer of steam turbines and helical reduction gears, has opened a district sales office in the Smith Bldg., Seattle, Wash., in charge of William Pullen.

Edward R. Ladew Co., Inc., manufacturer of leather belting, has removed its New York offices to more commodious quarters at 54-56 Franklin St., where it is equipped to meet requirements with prompt deliveries.

Jackson Machine Tool Co., Jackson, Mich., manufacturer of die-sinking machines, is erecting a new building 280 by 132 feet to provide better facilities for taking care of the rapidly growing demand for its die-sinking machines.

Mott Sand Blast Mfg. Co., 893 E. 134th St., New York City, will occupy its new plant in Brooklyn early in April. The plant has been fitted up with facilities for manufacturing sandblast and allied equipment, in which the company specializes.

J. R. Stone Tool & Supply Co., 24 Goebel Bldg., Detroit, Mich., has been given the agency for the sale of machine tools built by the Greaves-Klusman Tool Co., Cincinnati, Ohio, and will act as exclusive representative in eastern Michigan, Detroit territory.

Wood Turret Machine Co., Brazil, Ind., manufacturer of the "Tilted Turret" screw machine and the automatic chucking turret lathe, has completed a new office building and an addition to its factory that will increase the manufacturing facilities about 50 per cent.

Standard Parts Co., Cleveland, Ohio, a consolidation of the Standard Welding Co. and the Perfection Spring Co., has purchased control of the Bock Bearing Co., Toledo, Ohio. William E. Bock, president of the Bock Bearing Co., has been made a director of the Standard Parts Co.

Lansing Stamping & Tool Co., Lansing, Mich., manufacturer of internal grinding machines and stampings of all kinds, has made plans for the erection of a large factory in the near future to provide better means for taking care of the phenomenal demand for its internal grinder and stampings.

Burdett Oxygen Co., Chicago Ill., has completed the erection of an oxygen plant at Salt Lake City, Utah, and is now in a position to furnish pure oxygen to users in the Salt Lake City territory. The new plant is one of a chain erected by the Burdett Oxygen Co. The capacity of its Los Angeles plant was recently increased 50 per cent.

Dodge Mfg. Co., Mishawaka, Ind., has acquired the properties and control of the products of the Oneida Steel Pulley Co. and the Keystone Steel Pulley Co., both of Oneida, N. Y. This purchase brings under one management the production of Dodge wood and iron solid and split pulleys, and "Oneida" and "Keystone" steel split pulleys.

Kelly Reamer Co., Cleveland, Ohio, has increased its factory floor space 50 per cent. The added facilities were required to take care of the greatly increased volume of orders for Kelly reamers received from automobile, steam pump and engine builders. The pay of the factory and office employes has been raised 10 per cent as a partial offset to the high cost of living.

Bradford-Ackermann Corporation, Forty-second St. Bldg., New York City, a corporation recently formed by A. H. Ackermann and C. C. Bradford, announces that arrangements have been concluded with Ashton, Laird & Co. for the sole selling rights of "Astra" high-temperature gas apparatus and oxygen welding appliances, manufactured from the designs and patents of E. Raven Rosenbaum.

Asia Publishing Co., 280 Madison Ave., New York City, has started a monthly magazine devoted exclusively to the Orient and our relations with it, called "Asia." The new magazine is to be run on broader lines than a trade paper, the effort being to convey through the publication an interpretation of the life and spirit of China, Japan, and other great Oriental countries, in terms of their industrial progress.

High Speed Tools Corporation, 71 Broadway, New York City, has taken over the business of the Boerder Process Steel Co. of Toledo, Ohio. The new concern will engage in the manufacture of high-speed steel milling cutters, twist drills, reamers, and other tools cast by the Boerder process. It is incorporated under the laws of New York state with a capital of $1,000,000. Ernest Wolfes is the president, and A. Boerder is general manager.

Reynolds Pattern & Machine Co., Moline, Ill., has moved its plant to Massillon, Ohio. The company was recently incorporated under the laws of Ohio, with a capital of $200,000 and the name changed to the Reynolds Machine Mfg. Co. The board of directors have elected Floyd C. Snyder, president; Oliver F. Binford, secretary and treasurer; E. H. Birney, vice-president; and George D. Reynolds, general manager. Mr. Reynolds was general manager of the Moline plant, which employed about one hundred men.

Rider-Ericsson Engine Co., 20 Murray St., New York City, has been reorganized and plans have been made to extend the business of the company materially. The new officers are Samuel Andrews, president; A. W. Christianson, vice-president and general manager; Sanford Abrams, treasurer; and D. C. Dominick, secretary. The company is prepared to supply the trade with "Reeco" water supply systems, consisting of power pumps, gasoline and kerosene engines and pumpers, electric pumps, hot-air pumping engines, towers and tanks, pneumatic tanks and electric lighting plants.

Brown's Copper & Brass Rolling Mills, Ltd., New Toronto, Ontario, Canada, has awarded the contract to the Southwark Foundry & Machine Co., Philadelphia, Pa., covering the installation of a 2000-ton hydraulic extrusion press equipment for the manufacture of brass rod. The extrusion press will be in operation early in May; and with the present equipment in the company's new rod mill the output will be increased to over 5,000,000 pounds of finished rods monthly. The new mill for sheet metals will be in full operation in May, and the capacity will also be over 5,000,000 pounds monthly. The company has erected a large office building adjacent to its mills on the Lake Shore Boulevard.